An Assessment of Dead Wood Standards and Practices in Minnesota

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Ross N. Brown, Alan R. Ek, and Michael A. Kilgore[1,2]

Abstract

Through a review of existing data and literature, the amount of dead wood in Minnesota forests, its importance to forest health, the policies that guide sustainable dead wood management, and the level of compliance with dead wood guidelines are described. USDA Forest Service Forest Inventory and Analysis (FIA) monitoring efforts indicate there is a sizable and diverse supply of dead wood in Minnesota's nearly fifteen million acres of timberland. There are almost eight cords of coarse woody debris (CWD) per acre on Minnesota's timberlands. Federal timberlands have the highest density of dead wood, averaging over ten cords per acre. Scientific review indicates retention of dead wood in Minnesota forests contributes to ecological benefits such as wildlife habitat, improved water quality, and soil productivity.

Minnesota's Timber Harvest and Forest Management guidelines (TH/FM guidelines) are the standard for sustainable forest management in Minnesota, and provide the most specific recommendations for dead wood management across the state. They are also the standard used by certification organizations Forest Stewardship Council (FSC) and Sustainable Forestry Initiative (SFI). The TH/FM guidelines recommend leaving at least two to five down logs greater than twelve inches in diameter per acre. Standing dead trees should be left alone and slash should be scattered across the site whenever possible.

Most forest landowners consult the guidelines prior to applying forest management practices. Field monitoring efforts indicate the guidelines' dead wood management recommendations are met approximately 75% of the time. Nonindustrial private forest (NIPF) landowners are becoming a larger portion of the timberland ownership structure in the Minnesota; however, they have the lowest guideline compliance rate of any ownership group. A comparison of two different post-harvest monitoring efforts suggests UPM Blandin sites leave at least as much residual dead wood as the average site in Minnesota, possibly more.

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[2] Research was supported by UPM Kymmene and the Department of Forest Resources, College of Food, Agricultural and Natural Resource Sciences, University of Minnesota, St. Paul, MN, USA.

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I. INTRODUCTION

This report is part of an international effort to help describe forest management practices in different areas of the world. The motivation for this work has been UPM Kymmene's interest in parallel testing of forest certification standards. The international effort provides a broad understanding of how forests and forest management differ given various ecologic, political, and social influences. This report is one of a series that seeks to compare the forest characteristics and forest management practices between Minnesota and other parts of the world.

The specific subject of interest in this report is dead wood in forests, particularly the amount, quality, and importance of dead wood for biodiversity in forest management. For the purposes of this report, dead wood is defined as a dead branch or part of a tree that is on the forest floor. Dead wood includes standing dead trees, coarse woody debris, fine woody debris, and slash, but does not include foliage. As part of this international assessment, information about the amount of dead wood in Minnesota, its importance to forest sustainability, the standards that guide dead wood management and whether these standards are being met are described.

The report begins with a brief description of Minnesota's forest ownership structure and the legal and institutional setting for forestry in Minnesota to provide a general context for examining the issue of dead wood management in Minnesota. Subsequently, the report estimates the total inventory of dead wood in Minnesota, its general characteristics, and its importance using existing data and reports. Finally, the guidelines for dead wood management in Minnesota and the extent to which they are effective are examined.

II. MINNESOTA FOREST RESOURCE MANAGEMENT FRAMEWORK

A. Forest Ownership Structure

The nearly 15 million acres of timberland[3] in Minnesota have a diverse ownership structure. Figure 1 shows the breakdown of timberland in Minnesota by ownership group.[4] Nonindustrial private forest (NIPF) landowners own the largest amount of timberland in Minnesota (41%), followed by the state government (26%) and county governments (14%). The USDA Forest Service owns only 12% of the timberland, and other federal organizations own an additional 2%. Of the private timberland, NIPF comprises approximately 90%, and forest industry owns 10%.

[3] This report attempts to address lands classified as timberland, but in some instances data was only available for all forest land. As classified by the USDA Forest Service's Forest Inventory and Analysis (FIA) program, timberland is a subcategory of forest land. Timberland is "forest land that is producing or capable of producing in excess of 20 cubic feet per acre per year of wood at culmination of mean annual increment" and is not legally reserved from timber harvesting (Bechtold and Patterson 2005). There are approximately 16.3 million acres of forest land in Minnesota, with nearly 15 million acres in the subcategory of timberland (USDA Forest Service, 2006).

[4] A full description of the ownership groups and how they were sampled is provided by Miles et al. (2001).

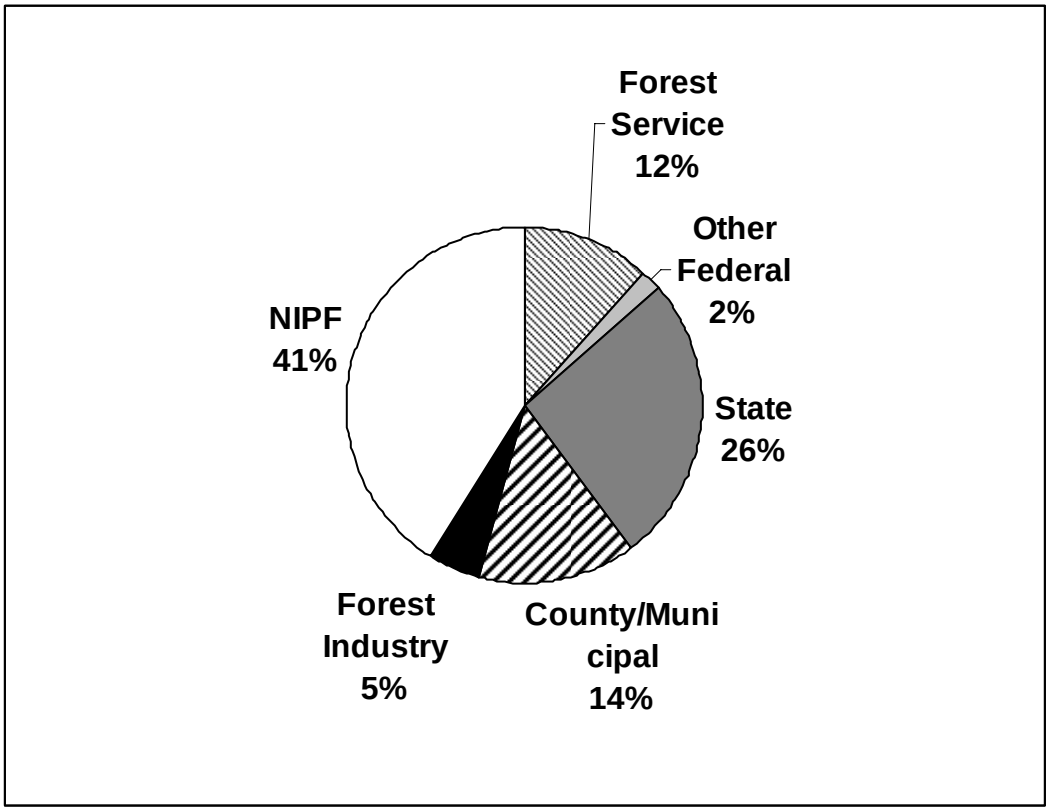

Figure 1. Distribution of MN timberland by ownership group.
Source: USDA Forest Service, 2006.

The NIPF owners hold the vast majority of private forest land in the state and may be increasing their share of ownership. Data from Kilgore and McKay (In Press) indicates that individual forest landowners are buying more forest land than they have been selling in recent years. This finding suggests that, in the future, even more of the private timberland in Minnesota will be held by individuals and families, instead of companies and businesses. If true, this trend could have significant impacts on the management of these lands.

Table 1 shows the distribution of timberland area by forest type and ownership group. Black spruce, northern hardwoods, lowland hardwoods, and aspen occupy the largest amount of timberland, each covering more than 1 million acres. Aspen is by far the most common forest type in Minnesota, covering almost 5 million acres.

Table 2 shows the breakdown of timberland area by stand size class and ownership group. The stand size classes are determined by observing whether the predominant tree size for the stand falls under one of these three diameter categories (Miles et al., 2001):

Small - < 4.9 inches dbh (seedlings/saplings),
Medium - 5 – 8.9 inches dbh (softwoods) / 5.0 – 10.9 inches dbh (hardwoods),
Large - 9.0+ inches dbh (softwoods) / 11.0+ inches dbh (hardwoods)
Nonstocked – less than 10 percent stocked trees of any size

Table 1. Timberland area by ownership and forest type (thousand acres).

	Ownership group						
Forest type	**Total**	**Forest Service**	**Other federal**	**State**	**County/ municipal**	**Forest industry**	**NIPF**
Jack pine	356	71	14	73	53	42	103
Red pine	562	148	15	123	50	48	177
White pine	151	47	1	17	14	6	66
Balsam fir	393	80	17	94	56	27	120
White spruce	111	26	1	41	7	14	22
Black spruce	1,334	213	19	632	221	34	215
Tamarack	868	70	11	452	139	8	188
Northern white-cedar	572	84	12	267	89	24	96
Eastern red cedar	26	0	0	3	0	0	22
Other softwoods	6	0	0	0	0	0	6
Oak	791	2	15	92	52	7	624
Northern hardwoods	2,058	143	30	287	244	34	1,320
Lowland hardwoods	1,104	66	18	232	113	39	635
Cottonwood/willow	107	4	8	25	5	9	56
Aspen	4,849	531	72	1,163	858	342	1,881
Birch	999	236	19	224	164	30	326
Balsam poplar	464	23	7	128	55	34	217
Non stocked	228	16	3	95	23	6	84
Total	14,978	1,761	263	3,947	2,144	705	6,158

Source: USDA Forest Service, 2006.

The total areas in large, medium, and small diameter stand size classes are similar. There is slightly less acreage of small diameter stand size classes (4,003,000 acres) than medium and large diameter stands size classes (5,688,000 and 5,057,000 acres respectively). For most ownership groups, medium diameter stand size classes cover the largest area of timberland. Nonindustrial private forest landowners have, by far, the largest acreage of small diameter stands, more than 2.1 million acres.

More specific forest types and age classes can be found by using the USDA Forest Service's Forest Inventory and Analysis (FIA) database. Appendix A contains detailed tables describing the distribution of timberland by ownership group, stand size class, and forest type. Further queries about forest land and timberland distribution in Minnesota can be developed from the FIA website at http://www.fia.fs.fed.us.

Table 2. Timberland area by ownership and stand size class (thousand acres).

	Ownership group						
Stand size class	**Total**	**Forest Service**	**Other federal**	**State**	**County/ municipal**	**Forest industry**	**NIPF**
Large diameter	5,057	614	56	1,691	791	394	1,511
Medium diameter	5,688	622	124	1,445	851	210	2,437
Small diameter	4,003	509	80	714	479	95	2,125
Non stocked	229	16	3	95	23	7	84
Total	14,978	1,761	263	3,947	2,144	705	6,158

Source: USDA Forest Service, 2006.

B. Legal and Institutional Setting

Concerns about the potential impacts of increasing timber harvest levels in Minnesota led to the creation of a Generic Environmental Impact Statement (GEIS) in 1994 (Jaakko Poyry Consulting, Inc., 1994). Along with an assessment of environmental impacts at different levels of statewide timber harvesting, recommendations were developed to mitigate the adverse impacts identified in the assessment. The recommendations for implementing the site-level and landscape-based recommendations contained in the GEIS became the basis for the implementation actions specified in the Minnesota Sustainable Forest Resources Act (SFRA) (MN § 89A) enacted in 1995 (Minnesota Statutes, 2004). The SFRA established and defined the institution responsible for coordinating implementation of GEIS recommendations: the Minnesota Forest Resources Council (MFRC). The implementation of the GEIS recommendations eventually led to the creation of Minnesota's Timber Harvesting and Forest Management Site-level Guidelines (TH/FM guidelines) (Dahlman and Phillips, 2004).

The TH/FM guidelines are designed to encourage forest ecosystem sustainability. Deadwood is an important component of forest ecosystem sustainability. The SFRA required that Minnesota's site-level guidelines "reflect a range of practical and sound practices based on the best available scientific information" (Minnesota Statutes 2004). In response to this mandate, the MFRC convened four multidisciplinary technical teams in 1996 to develop guidelines for riparian zone management, wildlife habitat, historic/cultural resources, and forest soil productivity. The technical team guidelines were developed through consensus over a two-year period and integrated to produce a single set of guidelines (Minnesota Forest Resources Council, 2005). They also incorporated the already existing best management practices (BMPs) for water quality, wetlands, and visual quality (Phillips et al., 1994). The guidelines were peer reviewed by several scientists, forest managers, and loggers before being released in 1998. Since then, the MFRC has sponsored additional peer reviews and public reviews to modify the guidelines once improved information on guideline effectiveness becomes available. The current version of the guidelines was released in June 2005. As a result, the TH/FM guidelines may be a good indication of what available science suggests about dead wood in Minnesota's forests

The TH/FM guidelines are the operating standard in Minnesota. They are nonregulatory and "serve as a menu, not a mandate" (Minnesota Forest Resources Council, 2005). The guidelines attempt to address a broad range of important values associated with timber harvesting and forest management activities.

III. IMPORTANCE OF DEAD WOOD

Since the site-level guidelines reflect a synthesis of the best available scientific information for Minnesota forests, this report will use the guidelines to describe how dead wood is important to forest sustainability in Minnesota. The following discussion

was drawn largely and directly from the 2005 version of the TH/FM guidelines (Minnesota Forest Resources Council, 2005).

Within the guidelines, deadwood is identified as important to three major forest benefits: (1) providing wildlife habitat; (2) protecting soil productivity; and (3) protecting riparian areas and water quality.

A. Providing Wildlife Habitat

"Coarse woody debris and slash provide cover, food or growing sites for certain amphibians, reptiles, mammals, birds, invertebrates, fungi and green plants. Salamanders, snakes, small mammals and birds benefit most from coarse woody debris and slash. Small mammals dependent on slash and coarse woody debris in turn provide food for mammalian carnivores and forest raptors (such as the pine marten and the northern goshawk). A variety of invertebrates, soil microorganisms and plants also benefit from the niches created by down logs" (Minnesota Forest Resources Council, 2005).

Coarse woody debris may also benefit reptiles and amphibians that breed elsewhere (in seasonal ponds) and then move to or disperse through the site being managed. Therefore, CWD may have an impact on reptiles and amphibians in off-site seasonal ponds (Minnesota Forest Resources Council, 2005).

"Snags provide for wildlife requiring perches, tree cavities and bark-foraging sites. In Minnesota, some 40 birds, 29 mammals, and several reptiles and amphibians use snags because they provide specialized substrates for nesting and/or foraging for birds and other species. Retention of snags during timber harvesting provides habitat for wildlife requiring perches, tree cavities and bark-foraging sites as the surrounding forest regenerates, by mimicking natural disturbances to some degree. Snags may also provide unique niches and microsites for a variety of plants, especially within retained clumps or as individuals fall over with time and begin to decay" (Minnesota Forest Resources Council, 2005).

B. Protecting Soil Productivity

Nutrient cycling is the process by which nutrient elements move into, out of, and within an ecosystem. The forested ecosystem in Minnesota receives natural inputs of nutrients through atmospheric deposition and geologic weathering. In Minnesota and adjoining states, nutrients that are of primary concern for forest growth are nitrogen (N), phosophorus (P), potassium (K), calcium (Ca) and magnesium (Mg). Complete understanding of nutrient use and sustainability requires not only knowledge of the amount of nutrients removed during the harvest (or through poor site preparation techniques), but also knowledge of the nutrient capital of the soil and the rates of natural additions and losses of these nutrients (Minnesota Forest Resources Council, 2005).

"A long-term view of forest nutrient status of an ecosystem must focus on the balance of inputs and outputs as they affect the nutrient capital. The nutrient capital can be considered to be a resource that can be used by trees, but whose availability depends on the internal dynamics of the system. If inputs of nutrients to a forest ecosystem exceed outputs from that system, then the nutrient capital in the system will increase. Conversely, if outputs exceed inputs, nutrient capital will decrease" (Jaakko Pöyry Consulting, Inc., 1992).

Outputs can occur through timber harvesting, removal of slash or surface soil during site preparation, burning, leaching or surface runoff. Most macronutrients that are removed from a site through timber harvest are replaced over the period of the rotation by nutrient inputs through such processes as precipitation, dust deposition and nitrogen fixation. Some notable exceptions are calcium after harvesting aspen stands, and phosphorous and potassium after harvesting on organic soils (Jaakko Pöyry Consulting, Inc., 1992).

Slash also provides shelter that mediates climatic extremes and contributes organic matter (nutrients and water-holding capacity) to forest soils (Minnesota Forest Resources Council, 2005).

"Retaining or redistributing slash on the site is important as a major nutrient retention strategy. This strategy is particularly important for nutrient-poor sites with soils that are: 1) predominantly deep, well-drained, or excessively well-drained sand; 2) predominantly deep organic soils (> 24 inches deep); or 3) predominantly shallow soils (< 8 inches deep) over bedrock" (Minnesota Forest Resources Council, 2005).

C. Protecting Riparian Areas and Water Quality

"Coarse woody debris helps to create and maintain pools, reduces stream velocities, forms eddies where food organisms are concentrated, supplies protection from predators, provides shelter during winter runoff, and traps and stores small debris from the forest. It also traps smaller debris, which then traps fine debris, sediment and organic matter and can lead to natural levee formation" (Minnesota Forest Resources Council, 2005).

Deadwood also affects aquatic ecosystems. The fine litter formed by the breakdown of decomposing plants, leaves and animals serves as the energy base for the aquatic food chain (Minnesota Forest Resources Council, 2005).

Removal of deadwood materials may also lead to increased soil erosion. Soil erosion is "the process by which soil particles are detached and transported by water, wind and gravity to some downslope or downstream point" (Jaakko Pöyry Consulting, Inc., 1992). Erosion is a natural process. Increased erosion that occurs due to human activity is considered to be accelerated erosion and perhaps the greatest factor controlling surface erosion in forests is the amount of vegetative cover and forest litter protecting the soil surface (Jaakko Pöyry Consulting, Inc., 1992).

IV. MINNESOTA DEAD WOOD ASSESSMENT

To fully understand forest management in Minnesota, it is important to know the extent and associated characteristics of dead wood in Minnesota's forests. The FIA program helps track the amount of snags, coarse woody debris, and fine woody debris on Minnesota's timberland.[5]

A. Snags

FIA data describes the number of standing dead trees that have a diameter at breast height (dbh) greater than 5 inches (Bechtold and Patterson, 2005). Standing dead trees, also known as snags, provide important wildlife habitat. Table 3 provides a breakdown of the total number of standing dead trees by ownership group[6] and stand diameter size class. Medium diameter stands have the largest number of standing dead trees (130 million). Also, state and local governments and private owners own land with the greatest total number of standing dead trees (114 million and 112 million). This result is not surprising considering these two ownership categories own the most timberland area (Figure 1).

Table 4 shows the average number of standing dead trees per acre by ownership and stand size class (obtained by dividing the total number of standing dead trees in a category (Table 3) by the corresponding timberland area). Results show that large and medium diameter stands have approximately the same number of snags per acre (23). Small diameter stands have much fewer snags (10). Also, USDA Forest Service lands and other federal ownership categories have more snags per acre (23 and 24 respectively) than the state and local governments and private ownership (19 and 17 respectively).

Table 3. Total number of standing dead trees on timberland by ownership and stand size class (thousands of trees).

	Ownership group				
Stand size class	**Total**	**Forest Service**	**Other federal**	**State and local**	**Private**
Large diameter	91,039	13,807	2,447	31,562	43,223
Medium diameter	130,341	17,212	3,363	59,111	50,655
Small diameter	48,642	8,400	434	22,116	17,691
Nonstocked	2,798	384	19	1,668	728
Total	272,820	39,803	6,263	114,457	112,296

Source: USDA Forest Service, 2006

[5] A full description of FIA field methods can be found in USDA Forest Service (2005).

[6] The total number of sample plots the FIA uses to measure dead wood materials is less than the number of sample plots used to determine timberland area by ownership group, stand diameter size, and forest type (Bechtold and Patterson, 2005). Therefore, there is not enough data to provide reliable estimates for all five ownership groups discussed in Section II. Instead, we use the four ownership groups noted in Table 3. NIPF and Forest Industry are combined into a "private" category. Also, county and municipal lands were categorized as "local" and combined with state lands.

Table 4. Average number of standing dead trees on timberland by ownership and stand size class (trees per acre).

	Ownership group				
Stand size class	**Total**	**Forest Service**	**Other federal**	**State and local**	**Private**
Large diameter	23	27	30	26	19
Medium diameter	23	28	27	26	19
Small diameter	10	14	8	9	9
Nonstocked	12	24	6	14	8
Total	18	23	24	19	17

Source: USDA Forest Service 2006.

Table 5 provides a breakdown of the number snags by ownership group and forest type.

Table 5. Total number of standing dead trees (DBH > 5") on timberland by ownership group and forest type (thousands of trees).

	Ownership group				
Forest type	**Total**	**Forest Service**	**Other federal**	**State and local**	**Private**
Jack pine	12,174	2,078	464	4,615	5,017
Red pine	8,761	2,363	216	2,754	3,428
White pine	3,761	1,178	17	1,060	1,506
Balsam fir	11,083	1,714	319	5,526	3,523
White spruce	1,007	434	88	184	300
Black spruce	18,588	4,412	535	10,966	2,674
Tamarack	9,888	1,942	0	5,294	2,652
Northern white-cedar	18,456	2,956	507	11,522	3,470
Eastern red cedar	117	0	0	56	61
Other softwoods	36	0	0	0	36
Oak	8,773	0	205	1,990	6,577
Northern hardwoods	30,986	2,900	462	8,317	19,307
Lowland hardwoods	18,395	994	146	7,071	10,184
Cottonwood/willow	1,141	91	557	146	348
Aspen	90,183	10,728	2,348	38,402	38,705
Birch	27,927	7,138	256	11,072	9,461
Balsam poplar	8,104	492	104	3,775	3,733
Nonstocked	2,760	384	19	1,668	690
Other	681	0	19	37	625
Total	272,820	39,803	6,263	114,457	112,296

Source: USDA Forest Service, 2006

Table 6 describes the average number of snags per acre by ownership group and forest type. Jack pine and northern white-cedar forest types have the greatest number of snags per acre in Minnesota (34 and 32, respectively). Eastern white pine, balsam fir, and birch stands also have a high density of snags per acre. Aspen forests, which cover the largest area of timberland in Minnesota, have a significantly lower number of snags per acre (19) than these forest types, but are near the state average (18).

Table 6. Average number of standing dead trees (DBH > 5") on timberland by ownership group and forest type (trees per acre).

	Ownership group				
Forest type	**Total**	**Forest Service**	**Other federal**	**State and local**	**Private**
Jack pine	34	29	32	37	34
Red pine	16	16	14	16	15
White pine	25	25	12	34	21
Balsam fir	28	22	19	37	24
White spruce	9	17	81	4	8
Black spruce	14	21	28	13	11
Tamarack	11	28	0	9	14
Northern white-cedar	32	35	42	32	29
Eastern red cedar	5	N/A	N/A	18	3
Other softwoods	6	N/A	N/A	N/A	6
Oak	12	0	19	14	12
Northern hardwoods	15	20	15	16	14
Lowland hardwoods	17	15	8	20	15
Cottonwood/willow	11	24	67	5	5
Aspen	19	20	32	19	17
Birch	28	30	14	29	27
Balsam poplar	17	21	16	21	15
Non stocked	12	24	6	14	8
Other	9	N/A	5	12	9
Total	18	23	24	19	16

Source: USDA Forest Service, 2006

B. Coarse Woody Debris and Fine Woody Debris

Another forest ecosystem indicator measured in the FIA program is the down woody materials (DWM) indicator (Woodall and Williams, 2005). The DWM indicator estimates dead organic materials and fuel complexes of live shrubs and herbs. The DWM indicator includes two components: fine woody debris (FWD) is defined as down woody pieces with a diameter of less than three inches; and coarse woody debris (CWD) is defined as downed pieces of wood with a minimum diameter of three inches and a length of at least three feet (Woodall and Williams, 2005). More on the sampling protocol, estimation, and analysis procedures of the DWM indicator can be found in Woodall and Williams (2005).

Average weights of CWD and FWD for all Minnesota timberland are shown in Figure 2. There are nearly four dry tons/acre of FWD and six tons/acre of CWD on Minnesota timberlands.[7] On average, Minnesota timberlands contain approximately 50% more CWD than FWD.

[7] 1 US ton per acre = 2.242 metric tons per hectare. See glossary for other conversion factors.

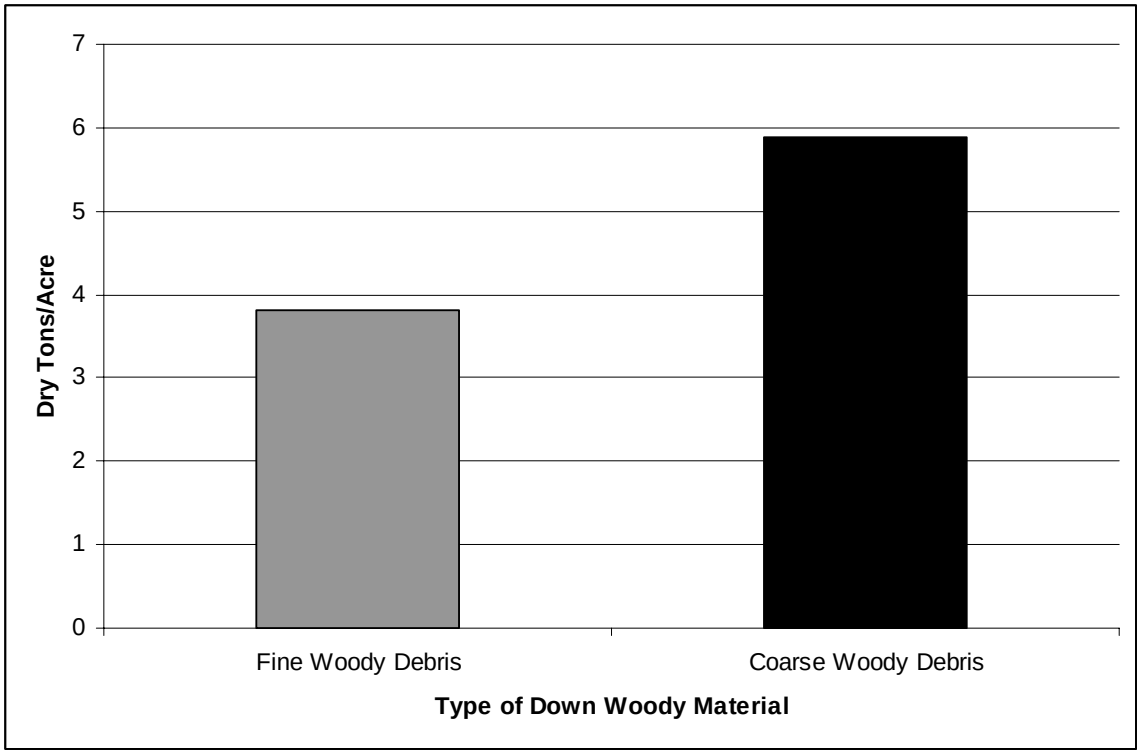

Figure 2. Distribution of average down woody material on Minnesota timberland.
Source: USDA Forest Service, 2006.
*FWD – diameter of less than 3 inches
*CWD- diameter of at least 3 inches and length of at least 3 feet

Table 7 and Figure 3 show the average amount of FWD and CWD on Minnesota's timberlands by ownership group.[8] USA Forest Service lands, on average, contain nearly twice as much CWD weight (9.33 tons/acre) as state and local government (4.68 tons/acre) and private owners (5.43 tons/acre).

Table 7. Average FWD and CWD on timberland by ownership group (tons per acre)**.**

Ownership group	Fine woody debris	Coarse woody debris
USDA Forest Service	4.59	9.33
State and local government	3.33	4.68
Private	4.07	5.43
Total	3.82	5.89

Source: USDA Forest Service, 2006.

[8] Since the "other federal" ownership groups do not manage much timberland in Minnesota, there is little data available for the amount of DWM on these lands. Therefore, the analysis of CWD and FWD in Minnesota is limited to USDA Forest Service, state and county government, and private lands.

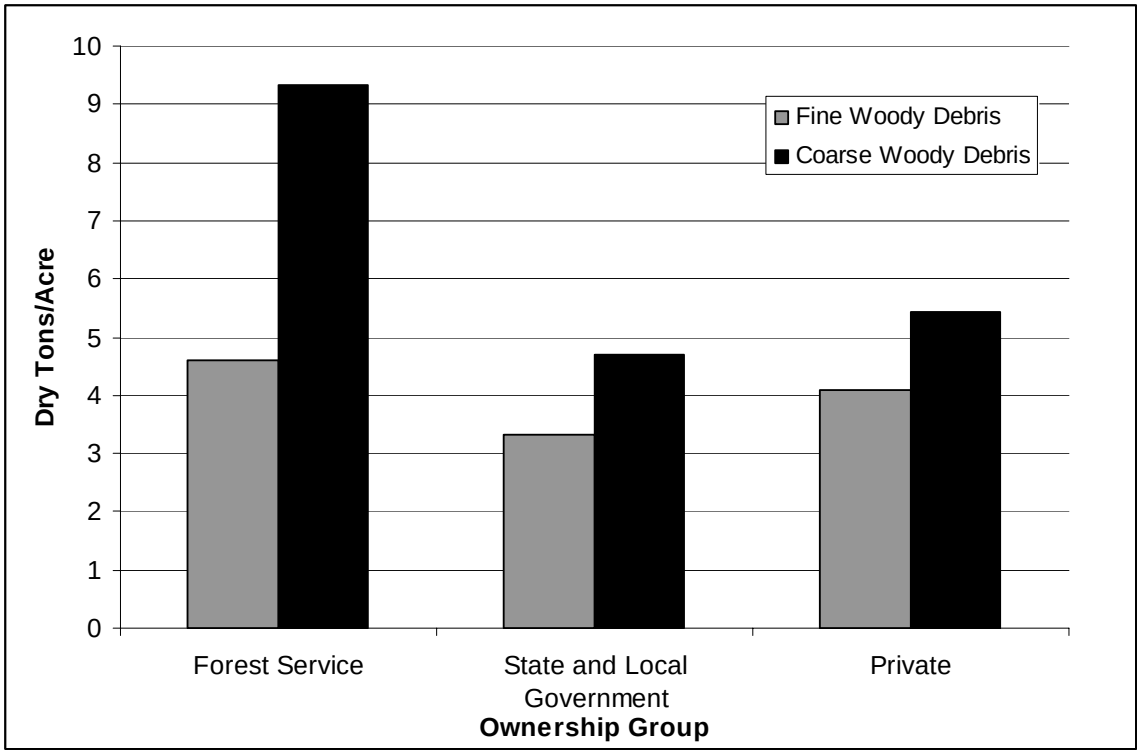

Figure 3. Average DWM on Minnesota timberlands by ownership group.
Source: USDA Forest Service, 2006.

Assuming a volume conversion of 1 cord = 91 ft^3, Table 8 and Figure 4 also show that USDA Forest Service lands contain much more CWD volume (10.81 cords/acre) than state and local governments (6.75 cords/acre) and private owners (7.53 cords/acre). Minnesota timberland averages 7.87 cords of CWD per acre.

Table 8. Average and total volume of CWD on timberlands by ownership group.[9]

Ownership group	Cords/acre*	Ft^3/acre	Estimated total ft^3
USDA Forest Service	10.81	984	1,731,962,543
State and local government	6.75	614	3,744,141,158
Private	7.53	685	4,705,432,648
Total	7.87	716	10,727,798,348

Source: USDA Forest Service, 2006.

[9] Total volume of CWD is estimated by multiplying the average cubic feet per acre by the total acres of timberland in Minnesota.

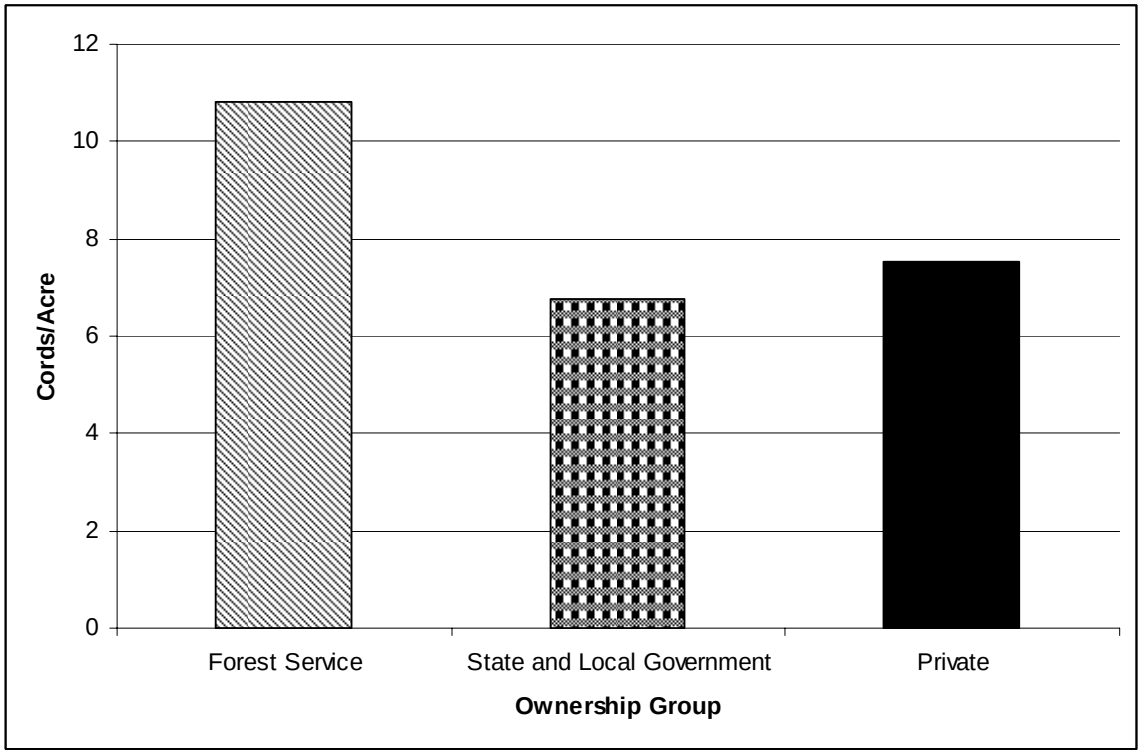

Figure 4. Average volume of CWD per acre on MN timberlands by ownership group.
Source: USDA Forest Service, 2006

Table 9 and Figure 5 provide more specific information about the size of CWD on the ground. The large majority of CWD pieces have a diameter smaller than eight inches. There are, on average, four dead logs with a diameter greater than thirteen inches per acre. Again, Forest Service lands have more CWD pieces than other ownership groups (Figure 6).

Table 9. Average number of CWD logs on MN timberlands by size of logs and ownership group (number of logs/acre).

	Size of CWD Log			
Ownership Group	**Diameter 3-7.9"**	**Diameter 8-12.9"**	**Diameter 13-17.9"**	**Diameter 18+"**
Forest Service	268	33	3	3
State and Local Government	156	21	1	1
Private	188	21	2	2
Total	188	23	2	2

Source: USDA Forest Service, 2006

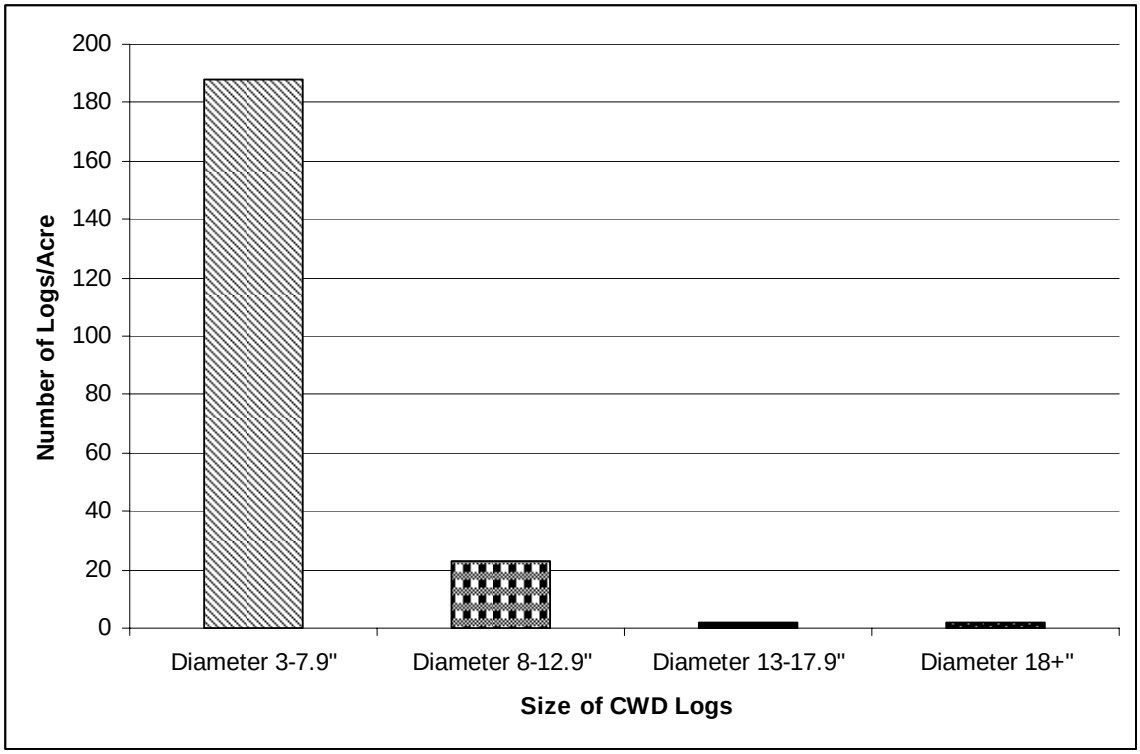

Figure 5. Average number of CWD pieces on MN timberlands by size of logs.
Source: USDA Forest Service, 2006

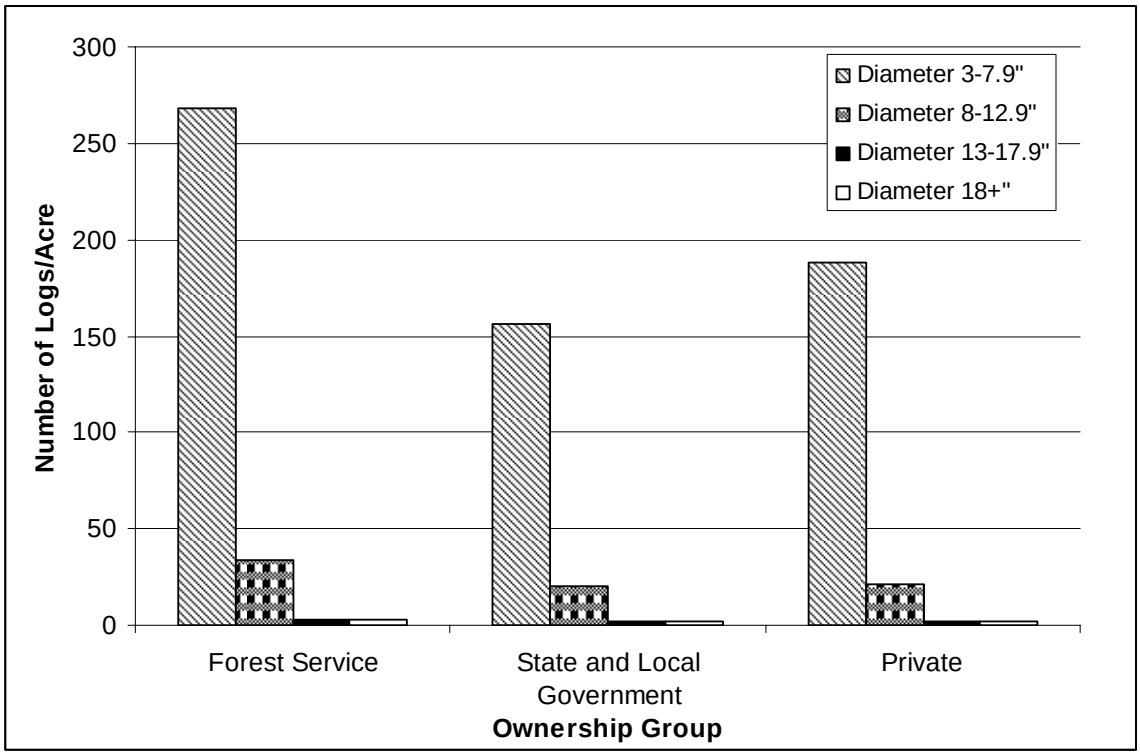

Figure 6. Average number of CWD pieces by size of logs and ownership group.
Source: USDA Forest Service, 2006

All dead wood on the ground is not in the same condition. Decay class is an FIA indicator that may explain the quality of the CWD on the ground (Woodall and Williams, 2005).[10] Table 10 gives the average number of CWD logs in each decay class by ownership group. Overall, decay class 3 is the most common type of CWD on Minnesota timberland (Figure 7).

Table 10. Average number of CWD pieces on MN timberlands by decay class and ownership group (number of logs/acre).

	Decay Class				
Ownership Group	**Class 1**	**Class 2**	**Class 3**	**Class 4**	**Class 5**
Forest Service	15.62	126.70	83.29	60.04	19.50
State and Local Government	11.85	26.15	88.42	39.18	14.05
Private	14.93	40.60	84.03	57.68	16.63
Total	14.01	47.87	86.21	51.28	15.61

Source: USDA Forest Service, 2006

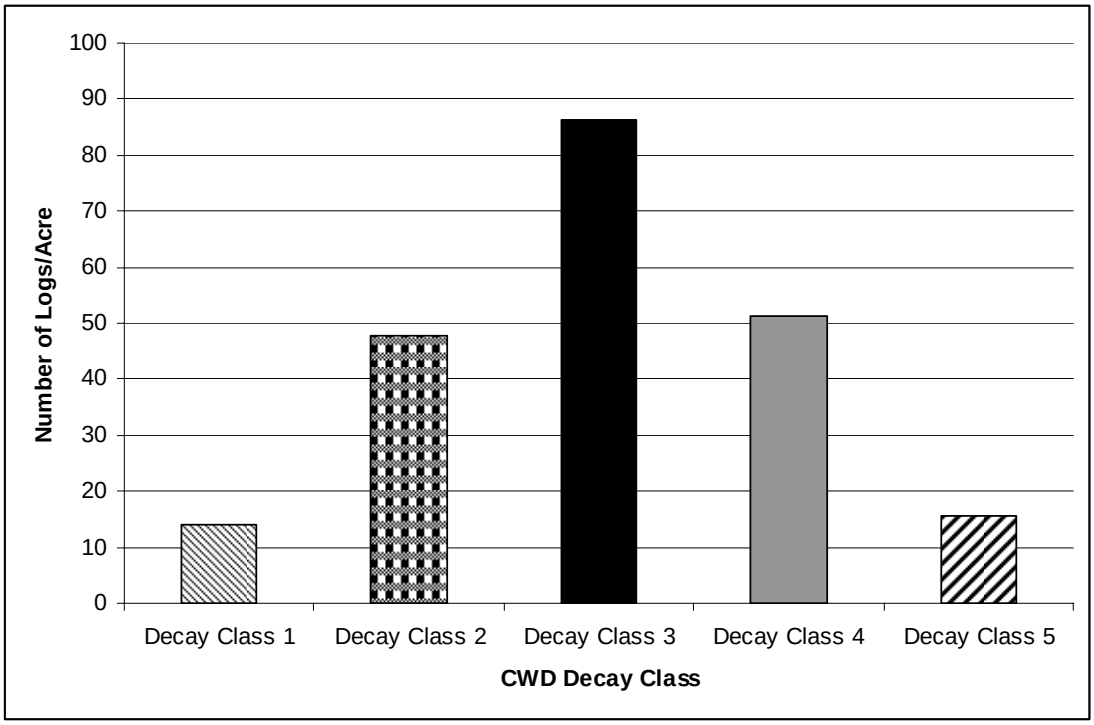

Figure 7. Average number of CWD pieces on MN timberland by decay class.
Source: USDA Forest Service, 2006

[10] Decay Class 1: sound logs, no rot, original color, not invading roots, if branches are present then fine twigs are still attached.
Decay Class 2: sound logs, starting to decay, original color, no invading roots, if branches are present then many fine twigs are gone.
Decay Class 3: heartwood sound, large pieces of rotten wood, reddish brown or original color, invading roots in sapwood, branch stubs will not pull out.
Decay Class 4: heartwood rotten but maintains own shape, redish or light brown, invading roots throughout, branch stubs pull out.
Decay Class 5: does maintain its shape, soft and powdery rotten portions, red-brown to dark brown, invading roots throughout, branch stubs have usually rotten down.

The distribution of CWD by decay class is similar for all ownership groups, except one. Forest Service lands average more CWD in decay class 2 than any other decay class (Figure 8). This is very different from state, local government, and private forest lands, where decay class 3 is the most common form of CWD.

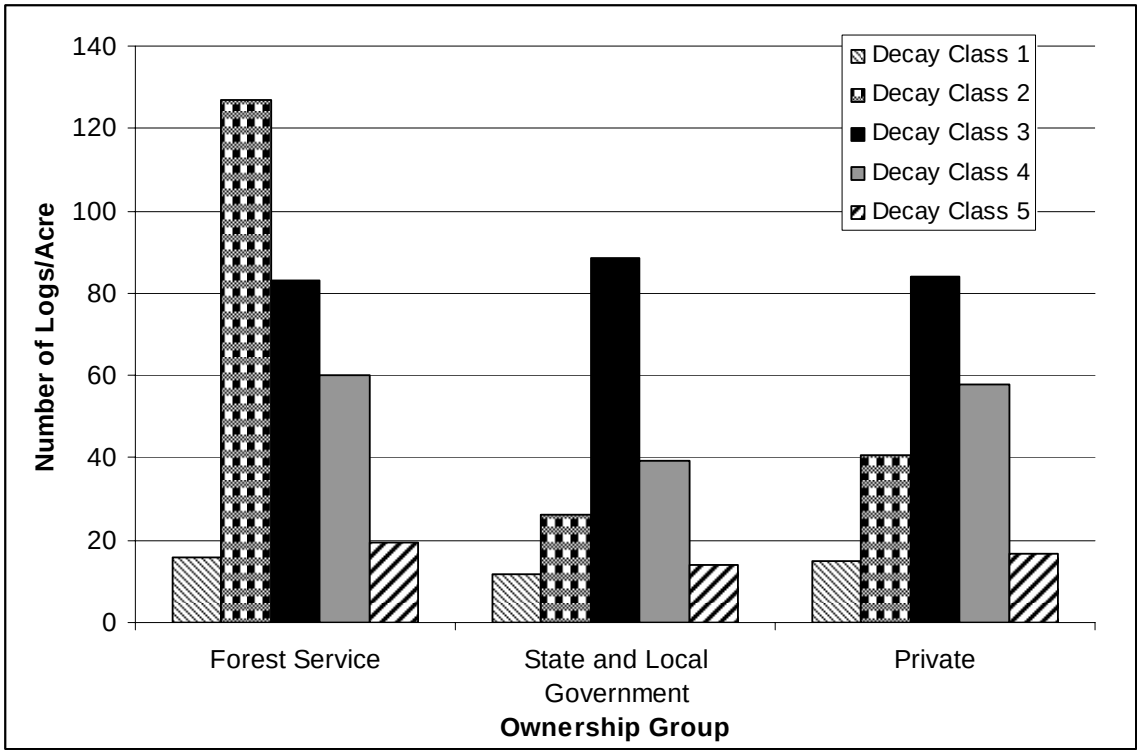

Figure 8. Average number of CWD logs on MN timberlands by decay class and ownership group. *Source:* USDA Forest Service, 2006

V. GUIDELINES FOR DEAD WOOD MANAGEMENT IN MINNESOTA

Minnesota does not have a regulatory system for specific timber harvesting or forest management practices. Instead, Minnesota uses voluntary TH/FM guidelines as a guide for sustainable forest management practices. Also, much of the Minnesota's timberland, including all state-owned timberland, is certified by the Forest Stewardship Council (FSC) and/or the Sustainable Forestry Initiative (SFI). Both of these certification organizations use the TH/FM guidelines as the standard for sustainable forest management. UPM Blandin uses these guidelines as its standard as well.

A. Minnesota Timber Harvesting/Forest Management Guidelines

Currently, the TH/FM guidelines do not have a specific section addressing the removal of dead wood. Instead, coarse woody debris, snags, and slash are all addressed in separate areas of the guidelines.

1. Coarse woody debris

The "General Guidelines" section of the forest management guidelines provides CWD recommendations. Coarse woody debris, as defined in the guidelines, is stumps and fallen trunks or limbs of more than 6-inch diameter at the large end. Coarse woody debris recommendations from the TH/FM guidelines are as follows (Minnesota Forest Resources Council 2005):

- Avoid having equipment disturb pre-existing large down logs, stumps and uprooted stumps.

- If a snag must be dropped, leave it where it falls whenever possible.

- Create at least 2-5 bark on down logs greater than 12 inches in diameter per acre, if fewer than this number already exist. In choosing candidates for leave logs, consider the following:
  - Hollow butt sections or other defective lengths of at least 6 feet are preferred.
  - Sound logs and 6-inch to 12-inch diameter logs may be used if they represent the best available candidates.
  - Hardwood logs have more hollows or cavities and are favored by certain amphibians.
  - Conifer logs decay more slowly and thus remain present as structure on a site longer than hardwoods.
  - Using pines as down logs, especially in summer, increases the risk of bark beetle damage to adjacent healthy pines.

- Scatter leave logs across the site, including a few near wetlands.

- If a site includes riparian areas, create 4 leave logs per acre in the riparian management zone, if fewer than this number already exists. The overall average number for the site, however, can remain at a minimum of 2 per acre.

- Exceptions to guidelines for providing coarse woody debris may be made for a number of reasons, including:
  - Alignment of skid trails
  - Specific silvicultural applications (such as insect pests)
  - Visual quality issues

2. Snags

The "Timber Harvesting" section of the guidelines provides guidance on treatment of snags, or standing dead trees during timber harvests. The recommendations for snags include the following (Minnesota Forest Resources Council 2005):

- Leave all snags possible standing in harvest areas.

- Exceptions to leaving all snags may be made for reasons related to visual quality. When leaving snags in areas classified as most sensitive or moderately sensitive:
  - Avoid leaving snags in the foreground.
  - Hide scattered snags with vegetative islands, or locate snags around the edge of an opening to allow for camouflage by background trees of similar color or texture.

Exceptions to the snag guidelines above can be made in the following circumstances:

- Operator safety (of loggers, aerial spray applicators and others).
- Public safety (hazard trees near rights-of-ways, recreation sites or airport vicinities).
- Specific forest management applications (such as genetic considerations for seed reproductions systems).
- Visual quality.
- Alignment of skid trails.
- Surrounding landscape concerns (sites adjacent to sharp-tailed grouse management units, for example).
- Forest insects and diseases (such as dwarf mistletoe on black spruce, gypsy moth and pine bark beetles).

"Although the guidelines address site-level recommendations for snags, the contribution of an individual site should be considered in the context of the surrounding landscape. Many of the cavity-dependent species being addressed have home ranges larger than the typical harvest unit, so planning for their needs requires a broader look, both spatially and temporally, at the larger forest community" (Minnesota Forest Resources Council, 2005).

"If suitable habitat exists surrounding a given harvest site to maintain populations of these species, then leave trees may not be as critical on that site. However, if harvests are likely in the adjacent habitats, then the trees left on the initially harvested sites become more important as the surrounding forest regenerates. Consideration must be given to the time it takes for a regenerating stand to produce trees of adequate size and degree of decay to provide suitable structure" (Minnesota Forest Resources Council, 2005).

"Consider reducing leave tree and snag requirements on harvest sites adjacent to agricultural lands (especially pastures) to reduce nest parasitism by cowbirds and nest predation. Note also that not all forest communities naturally provide snags; therefore,

across a given landscape, not all sites must be managed for snags" (Minnesota Forest Resources Council, 2005).

Coordination among neighboring landowners may result in varying numbers of leave trees on a site if adjacent lands exceed or fall short of the recommendations. Managers of larger landholdings may be able to plan for sufficient cavity-dependent wildlife habitat on portions of their property (such as riparian reserves) and reduce leave tree or snag requirements on other portions (Minnesota Forest Resources Council, 2005).

3. Slash

The TH/FM guidelines define slash as all residual woody material created by logging or timber stand improvement. Often this includes smaller pieces of wood, limbs or branches that are not large enough to be considered coarse woody debris. The "Timber Harvesting" guideline section provides the following suggestions for managing slash (Minnesota Forest Resources Council, 2005):

- Favor practices that allow for dispersed slash on the site, rather than piling slash, where dispersed slash does not conflict with management objectives or reforestation. When piling slash, piles should be kept away from cultural resources.

- If moving slash on-site is desirable, use equipment that minimizes soil disturbance.

- Keep logging residue out of all streams, lakes and open water wetlands, except in cases where residue placement is specifically prescribed for fish or wildlife habitat. Make reasonable effort to keep logging residue out of all seasonal ponds and nonopen water wetlands.

The positive benefits to retaining or redistributing slash on the site must be balanced with the need to safely and efficiently operate equipment on the site, to regenerate the stand, and to minimize the potential for additional compaction that might occur from redistributing the slash (Dahlman and Phillips 2004).

4. Draft biomass harvest guidelines

A mandate from the 2005 Minnesota Legislature requires that the MFRC develop guidelines for best management practices for "sustainably managed woody biomass" for forest land by July 1, 2007 (M.S. 216B.2424). A 12-member interdisciplinary technical committee will develop the guidelines. The Biomass Harvesting Guidelines, when complete, will be inserted into the already existing TH/FM guidelines. The biomass guidelines will focus on the harvest of biomass while protecting the soil, water, and habitat essential to a healthy and sustainable ecosystem (Minnesota Forest Resources Council, 2006). The purpose will be to "provide guidance to natural resource managers, loggers, equipment operators, contractors, and landowners to assist them in making

informed and appropriate decisions regarding biomass harvest on forestland sites" (Minnesota Forest Resources Council, 2006). Many states have addressed treating, burning, and disposing of biomass residue to reduce fire. However, Minnesota is likely the only state that has specifically addressed biomass harvests through guidelines.[11]

The biomass harvest guidelines are currently in draft form and are currently subject to a peer review.[12] The final draft will not be complete until later in 2007. Many of the guidelines regarding coarse woody debris and snags will likely be identical to existing TH/FM guidelines. However, when complete, the new biomass harvest guidelines may provide more specific guidance for sustainable dead wood management in Minnesota. Some recommendations for dead wood management that are not finalized, but are included in the draft biomass harvest guidelines include[13]:

- Leave all snags possible standing in harvest areas.
- Snags cut for safety reasons should be left where they fall
- Retain and limit disturbance to all CWD (except those in skid trails or landings).
- Retain stumps and uprooted stumps.
- Avoid removal of CWD material from the forest floor in filter strips.
- Avoid biomass harvest from within RMZs over and above the tops and limbs of trees normally removed in a roundwood harvest under existing timber harvesting guidelines.
- Retain and scatter tops and branches from 20% of trees harvested in the general harvest area (1 out of every 5 trees harvested).
- The over-all goal for FWD retention is to retain about 1/3 of the FWD on a site. This is achieved by intentionally retaining 20% of the FWD (tops and limbs from 1 in 5 trees harvested), with an additional 10–15% achieved by incidental breakage during skidding. Usually more breakage occurs in winter than in summer.
  Examples:
  - When using a cut-to-length system, the tops and branches from 1 tree out of 5 should be processed and left on the site. The tops and limbs from the remaining 4 trees could be piled for utilization as biomass.

[11] Personal communication with Dalia Saleh, University of Minnesota, Department of Forest Resources.
[12] Personal communication with Dick Rossman, MN DNR Division of Forestry, January 2007.
[13] Draft version of biomass harvest guidelines as of January 25, 2007.

- When utilizing a full tree skidding operation, the tops and limbs from 1 in 5 trees processed at the landing should be hauled back out and scattered on the general harvest area.

- Avoid removing tops and limbs resulting from incidental breakage from the general harvest area.

- If harvesting brush and small trees for biomass associated with a timber harvest, leave 20% of this material on the site (this material can be run over or cut, but should remain on the site).

When complete, the final draft of the biomass harvest guidelines will provide detailed guidance for dead wood treatment during timber harvests and biomass harvests.

B. Certification Standards

Another influential standard for dead wood management is forest certification. Forest certification plays an important role in forest management decisions on much of Minnesota's forest land.

Two major certification organizations in Minnesota are the Forest Stewardship Council (FSC) and the Sustainable Forestry Initiative (SFI). More than 6 million acres of forest land in Minnesota are certified by each organization (Metafore, 2005). Together, these two organizations certify 7,130,194 acres of forest land in Minnesota. Almost all of this land is owned by state and local governments or private companies. The largest owner of certified forest land in Minnesota is the Department of Natural Resources (MN DNR), with 4,839,735 acres. UPM has its acres of Minnesota forest land SFI and ISO 14,001 certified. [14]

SFI and FSC have separate standards for the proper management of dead wood during timber harvest. Under both certification systems, the most important certification standard for dead wood management is the set of local guidelines, or best management practices (BMPs). BMPs vary across different regions of the country and the world, so the specific requirements for dead wood can change significantly depending on where the forest is located. In Minnesota, the TH/FM guidelines represent BMPs for timber harvest and forest management. As such, they are the certification standard for dead wood management in Minnesota.

In addition to local BMPs, certification organizations may provide specific requirements for dead wood management. Landowners and forest managers must meet these additional requirements for certification, regardless of local BMPs.

[14] The International Standards Organization (ISO) certification system is not discussed in this report. More information on this standard can be found at http://www.iso.org/iso/en/aboutiso/introduction/index.html.

1. Forest Stewardship Council (FSC)

The most important FSC certification standard is compliance with BMPs for the forest region. Section 6.5 of the FSC Lake States Standard, which are applicable to Minnesota forest lands, states that the local "written guidelines shall be prepared and implemented to control erosion; minimize forest damage during harvesting, road construction, and all other mechanical disturbances; and to protect water resources" (Forest Stewardship Council, 2005). As part of this requirement, the FSC states the following:

> *The Lake States-Central Hardwoods Regional Certification Standards cover a diverse landscape-from prairie to glaciated Northern lands to unglaciated forests in the South. Within this region, all States have developed best management practice guidelines specific to their ecological conditions. These locally developed guidelines serve as the base requirements for implementation of this standard.*

To further this point, Section 6.5.a requires:

> *A set of forestry best management practices (BMPs), approved by the state forestry agency or otherwise appropriate jurisdiction, that address water quality and soil erosion is adhered to. These guidelines may include provisions on riparian management zones (RMZs), skidding, access roads, site preparation, log landings, stream crossings, disturbance of sensitive sites, and wetlands.*

Also, 6.5.b requires that, at a minimum, the implementation of BMPs result in the following:

> *Slash is concentrated only as much as necessary to achieve the goals of site preparation and the reduction of fuels to moderate or low levels of fire hazard.*

Along with following BMPs, the FSC standard has a few specific requirements for sustainable dead wood management. Principle 5.3 of the FSC Lake States Standards requires that "forest management minimize waste associated with harvesting and on-site processing operations and avoid damage to other forest resources" (Forest Stewardship Council, 2005). More specifically, sections 5.3.a. and 5.3.b. address dead wood management. Section 5.3.a. of the FSC Lake States Standards, requires that:

> *Adequate quantities and a diversity of size classes of woody debris (considered a reinvestment of biological capital under this criterion-not an economic waste) are left on the forest floor to maintain ecosystem functions, wildlife habitats, and future forest productivity.*

Also, section 5.3.b. requires that the "loss and/or waste of merchantable forest products is minimized."

Section 6.3.c. addresses "natural cycles that affect the productivity of the forest ecosystem." As a part of this principle, 6.3.c.1 requires that:

> *Biological legacies of the forest community are retained at the forest and stand levels, consistent with the objectives of the management plan, including but not limited to: large live and declining trees, coarse dead wood, logs, snags, den trees, and soil organic matter.*

Addressing soil productivity, section 6.3.c.2 requires:

> *Forest management practices maintain soil fertility and organic matter, especially in the A horizon, while minimizing soil erosion and compaction. If degradation of soil quality occurs, as indicated by declining fertility or soil health, forest owners or managers modify soil management techniques.*

2. Sustainable Forestry Initiative (SFI)

SFI standards also require that timber harvests follow local BMPs and provide proper protection of wildlife habitat and biodiversity through the retention of dead wood (Sustainable Forestry Initiative, Sustainable Forestry Board, 2004). Requirements for compliance with local BMPs are found in Performance Measure 3.1 of the SFI Standards. This measure requires:

- Program to implement state or provincial BMPs during all phases of management activities.
- Contract provisions that specify BMP compliance.
- Monitoring of overall BMP compliance.

Also, performance indicator 4.1.4 requires:

> *Development and implementation of criteria, as guided by regionally appropriate science, for retention of stand-level wildlife habitat elements (e.g., snags, mast trees, down woody debris, den trees, nest trees).*

There are no specific SFI standards for dead wood management that are not included in local BMPs.

C. UPM Guidelines

UPM Blandin uses the Minnesota TH/FM guidelines as a guide for forest management and timber harvesting.[15] These guidelines are the standard on UPM lands, as well as the rest of Minnesota's timberlands. Also, UPM lands in Minnesota are SFI certified, so they are required to follow all SFI standards for dead wood management.

[15] Personal communication with Cheryl Adams, UPM Kymmene Blandin Paper Company, January 2007.

VI. DEAD WOOD MANAGEMENT PRACTICES

The Minnesota TH/FM guidelines do not ensure proper forest management, as their application is voluntary. To fully understand how closely these guidelines are being followed, various monitoring efforts around the state were examined to assess whether foresters and loggers are following the guidelines and, specifically, dead wood recommendations.

Several different monitoring efforts in Minnesota elucidate how dead wood is managed in Minnesota forests. The University of Minnesota conducted a study to assess the implementation of various mitigation strategies suggested by a Generic Environmental Impact Statement (GEIS) released in 1994 (Kilgore et al., 2005). This study provided information on the level of compliance with the sustainable forest management guidelines. Also, the MFRC is required to conduct yearly monitoring to estimate the level of compliance with the Minnesota TH/FM guidelines. Similar to the study by Kilgore et al. (2005), the MFRC guideline monitoring provides information about how Minnesota's forests are being managed relative to specific timber harvesting practices.

Two separate monitoring efforts by the MN DNR Division of Forestry and UPM Blandin also provide information on the amount of dead wood left behind after harvests. Each of these efforts estimate the typical amount of dead wood left on Minnesota forest lands after harvests and, together, make it possible to compare UPM dead wood management and statewide dead wood management.

Finally, the MN DNR has nearly 5 million acres of its forest land FSC and SFI certified. The certification audits for these forest lands indicate how closely the MN DNR is following the certification standards for these organizations, which are essentially identical to the TH/FM guidelines. These certification audits can show how nearly one-third of the forest land in Minnesota is managed.

A. Generic Environmental Impact Statement (GEIS) Monitoring

In 2005, a study by Kilgore et al. was conducted to assess the level of implementation of various mitigation strategies recommended in the Minnesota timber harvesting GEIS (and later incorporated into the site-level guidelines). A survey was sent to the state's largest forest land managers to gather information regarding the level of knowledge and implementation of the site-level mitigation recommendations. The survey also asked these managers to rate their participation and the perceived usefulness of the landscape-level mitigation strategies implemented by the MFRC (Kilgore et al., 2005).

All of the organizations surveyed responded. The survey respondents accounted for 9,662,632 acres of forest land in Minnesota. The surveys provide valuable information about the level of overall guideline compliance and compliance related to deadwood management.

1. Overall guideline compliance:

Results from Kilgore et al. (2005) show that in 2005 all organizations indicated their practices are equal to or exceed those recommended in the guidelines (Table 11). Fifty-two percent of the forest land is subject to forest management practices that often or always exceed those practices recommended in the guidelines.

Table 11. Extent to which an organization's current timber harvesting and forest management practices are consistent with the guidelines.*

Organization	Extent to which practices are consistent with guidelines				
	Always exceed guidelines	**Often exceed guidelines**	**Consistent with guidelines**	**Often less than guidelines**	**Rarely or never meet guidelines**
Private					
Acres	30,000 (3)	534,183 (60)	320,000 (36)	0	0
Respondents	1 (14)	4 (57)	2 (29)	0	0
Public					
Acres	300,367 (3)	4,212,622 (48)	4,220,768 (48)	0	0
Respondents**	1 (6)	6.5 (41)	8.5 (53)	0	0
Total					
Acres	**330,367 (3)**	**4,746,805 (49)**	**4,540,768 (47)**	**0**	**0**
Respondents**	**2 (9)**	**10.5 (46)**	**10.5 (46)**	**0**	**0**

Source: Kilgore et al., 2005

* Numbers in parentheses represent corresponding percentages of total response.

** Fractions indicate that at least one respondent indicated acreages in multiple categories

2. Dead wood compliance

Data from Table 12 indicate that nearly 100% of forest land is managed under practices that are at least consistent with the guideline recommendation for snags and cavity trees. Only one private organization, managing less than 50,000 acres of forest land, indicated its snag and cavity tree practices are currently not meeting the guideline recommendations. Also, data suggests private organizations are more likely to exceed the guidelines than public organizations.

Table 13 shows the guideline compliance for retention of slash in 2005. Ninety-nine percent of the forest land represented by the survey is managed in a manner that is consistent with or exceeds the guidelines' recommended practices. Private organizations are more likely to exceed the guidelines than public organizations.

Table 12. Comparison of organization's 2005 practices regarding the retention of snags and cavity trees to those practices recommended in the guidelines.*

Organizations	Practices always exceeded guidelines	Practices often exceeded guidelines	Practices consistent with guidelines	Practices often less than guidelines	Practices rarely or never met guidelines
Private					
Acres	0	494,183 (53)	385,000 (42)	44,692 (5)	0
Respondents	0	3 (43)	3 (43)	1 (14)	0
Public					
Acres	300,367 (3)	3,913,722 (45)	4,519,668 (52)	0	0
Respondents**	1 (6)	4.5 (28)	10.5 (66)	0	0
Total					
Acres	**300,367 (3)**	**4,407,905 (46)**	**4,904,668 (51)**	**44,692 (<1)**	**0**
Respondents**	**1 (5)**	**7.5 (34)**	**12.5 (57)**	**1 (5)**	

Source: Kilgore et al., 2005
* Numbers in parentheses represent corresponding percentages of total response.
** Fractions indicate that at least one respondent indicated acreages in multiple categories.

Table 13. Comparison of organization's 2005 practices regarding the retention of slash to those practices recommended in the guidelines.*

Organization	Practices always exceed guidelines	Practices often exceed guidelines	Practices consistent with guidelines	Practices often less than guidelines	Practices rarely or never met guidelines
Private					
Acres	0	524,183 (57)	377,346 (41)	22,346 (2)	0
Respondents**	0	4 (57)	2.5 (36)	.5 (7)	0
Public					
Acres	300,367 (3)	1,769,824 (20)	6,614,666 (76)	48,900 (1)	0
Respondents	1 (6)	4 (25)	10 (63)	1 (6)	0
Total					
Acres	**300,367 (3)**	**2,294,007 (24)**	**6,992,012 (72)**	**71,246 (1)**	**0**
Respondents**	**1 (4)**	**8 (35)**	**12.5 (54)**	**1.5 (7)**	**0**

Source: Kilgore et al., 2005
* Numbers in parentheses represent corresponding percentages of total response.
** Fractions indicate that at least one respondent indicated acreages in multiple categories.

B. Minnesota Guideline Implementation Monitoring

In addition to the creation of the TH/FM guidelines, the SFRA also required monitoring of forest management practices on all forest lands in Minnesota to ensure that the guidelines are being followed. A monitoring program was implemented, beginning in 2000. The program objective was to evaluate the implementation of the guidelines through field visits to randomly selected recent timber harvest sites on state, county, national forest, tribal, other public agency, forest industry, other corporate, and NIPF lands (Dahlman and Phillips, 2004). The result was the Baseline Guideline Implementation Monitoring Report by Dahlman and Phillips (2004). This report discusses the findings of the first three years (2000-2002) of monitoring. It established a baseline of harvesting practices prior to publication of the TH/FM guidelines.

1. Landowner willingness to comply with guidelines

Table 14 from Dahlman and Phillips (2004) shows landowner willingness to apply timber harvest and forest management guidelines. Sixty percent (124 of 207) of the landowners who completed the landowner questionnaire indicated that the TH/FM guidelines had been used to plan or modify the plan for their timber harvest. State and county governments used the guidelines most often, 74% and 73% respectively. Only NIPF landowners did not use the guidelines to plan timber harvests often. They only consulted the guidelines 29% (10 of 34) of the time.

Table 14. Willingness of landowners to apply timber harvest and forest management guidelines (2001, 2002).

	Guidelines used to plan or modify timber harvest plan				
Landowner category	**Yes**	**No**	**No answer**	**N/A**	**Total**
State	54	19	0	3	76
County	45	17	3	0	65
Forest Service	8	5	0	0	13
Forest Industry	5	2	0	0	13
NIPF	10	24	9	0	43
Other	2	1	0	0	3
Total	124	68	12	3	207

Source: Dahlman and Phillips 2004
*TH=timber harvest
**Includes both landowners who did not provide information in the landowner questionnaire and sites where roads were not constructed, reconstructed, or used for timber harvest.

There were similar results for the survey question asking whether the guidelines were discussed on-site between resource managers and loggers (Table 15). The landowners and resource managers who responded indicated that they had discussed the TH/FM guidelines with the logger/contractor 61% (126 of 207) of the time regarding timber harvest. State and local governments discussed the guidelines most often (81% for both). Again, the NIPF owners only used the guidelines 41% of the time, the lowest percentage of any group.

Table 15. Discussion of guidelines between landowners and operators (2001, 2002)

	Guidelines discussed on-site between resource manager/landowner and logger/operator					
Landowner category	**Yes**	**No**	**No answer**	**Cannot determine**	**N/A**	**Total**
State	58	13	1	4	0	76
County	44	10	3	8	0	65
Forest Service	7	5	0	1	0	13
Forest Industry	3	2	0	2	0	7
NIPF	12	17	13	1	0	43
Other	2	1	0	0	0	3
Total	126	48	17	16	0	207

Source: Dahlman and Phillips, 2004.

Considering that the data collected for these two questions were based on information from timber harvest planning activities conducted prior to the publication of the TH/FM

guidelines, these results are somewhat surprising. The expected answer for both questions was "no" (Phillips and Dahlman, 2004).

Two reasons could explain the majority of these responses (Phillips and Dahlman, 2004):

1. Landowners/resource managers answered questions based on what they thought the authors wanted to hear. Some respondents may have been averse to indicating that they were not using the TH/FM guidelines.
2. Landowners/resource managers were answering the questions based on the application of the water quality and wetland BMPs that have been the forestry standard since 1995. These BMPs were incorporated into the comprehensive TH/FM guidebook.

2. Slash management

Slash management results are shown in Figure 9. Slash retained on the site at the stump was the most common method found and was applied on 55% of the sites. This is the preferred method of slash disposal for maintaining forest soil productivity on most sites. Twenty percent of the sites redistributed the slash at the site. Slash piled at landings and slash piled and burned occurred on 23% of the sites. Frequently this was done as part of preparing the site for replanting or as a means of pest control (Dahlman and Phillips, 2004).

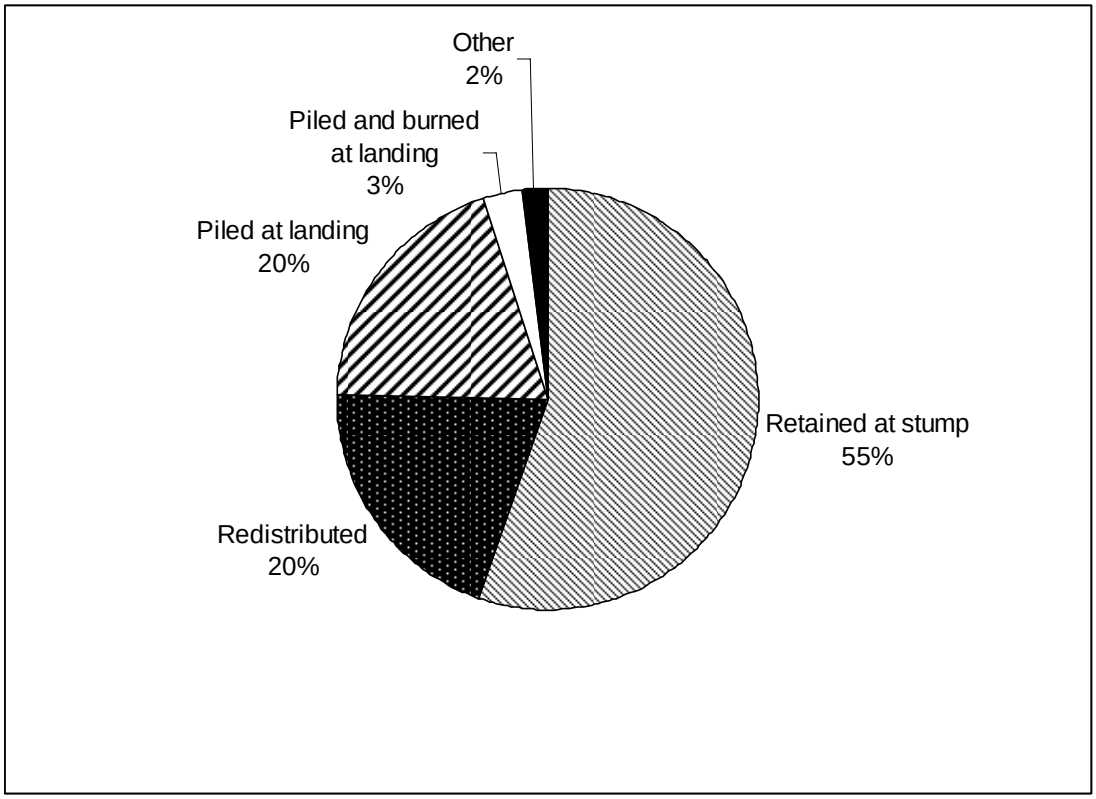

Figure 9. Slash Management (2000, 2001, 2002).
Source: Dahlman and Phillips, 2004.

The data makes it difficult to determine whether the guidelines for slash management are being followed. The fairly large number of sites that retain slash at the stump may suggest the guidelines are commonly followed, but since proper slash management may be different depending on the type of site, there is not enough information about the individual sites to know how often proper slash management is conducted.

3. Coarse woody debris

Monitoring results from 2000 reported that landowners were not meeting the guideline recommendation for coarse woody debris (Phillips, 2001). Only 21% and 22% of general harvest areas and riparian management zones, respectively, met the guideline recommendation for "bark-on" down logs (Phillips, 2001). It was suggested that, for many of these logs, the bark had sloughed off by the time the inspections were conducted. For monitoring in 2001 and 2002, the standard was modified to evaluate decay classes of "sound" down logs as described by Harmon et al. (1986) (Dahlman and Phillips, 2004).

Table 16. Bark-on down logs per acre for general harvest area and RMZ by landowner category (2001, 2002).

Landowner category	Bark-on down logs per acre (number of sites)					
	General harvest area			RMZ		
	<2	2-5	>5	<4	≥4	N/A
State	14	28	31	8	16	10
County	7	31	27	1	15	11
Forest Service	1	7	5	0	0	2
Forest Industry	2	3	2	2	0	1
NIPF	17	14	12	9	12	5
Others	1	0	2	0	0	0
Total	42	83	79	20	44	29

Source: Dahlman and Phillips, 2004.

The results for 2001 and 2002, seen in Table 16, indicate the guideline recommendation for leaving two to five "sound" down logs was met or exceeded 79% (162 of 205) of the time in general harvest areas. NIPF lands have the largest number of sites (17) that do not meet the recommended number of down logs. Twenty-nine of the 93 riparian zones (RMZs) identified in 2001 and 2002 were entirely nonforested or had no harvest activity. Sixty-nine percent (44 of 64) of the RMZs that did have harvest activity met the CWD guideline of leaving at least four down logs (Dahlman and Phillips, 2004).

4. Snags

The guideline monitoring defined a snag as a dead tree stem standing at least 8 feet tall and 6 inches DBH (diameter at breast height). In 2000, 80 of 104 sites retained snags, but the number per acre was not recorded. In 2001 and 2002, the recommendations for leaving snags applied to 175 of 207 sites, excluding thinning and shelterwood management. Over all three years, 94% (242 of 255) of the sites where the snag guideline applied did retain some snags. Seventy-two percent of the 2001-2002 sites retained at

least one snag per acre, with 37% of sites having more than two snags per acre (Table 17 and Figure 10) (Dahlman and Phillips, 2004).

The TH/FM guidelines are not specific in recommending numbers of snags on the timber harvest site. The lack of specific guidance makes it difficult to determine whether the guideline is being met (Dahlman and Phillips, 2004).

Table 17. Number of MN timber harvest sites with snags retained for vertical structure (2001, 2002).

	Snags/acre			
	0	**<1**	**1-2**	**>2**
Number of sites	13	36	62	64
Percent (%)	7	21	35	37

Source: Dahlman and Phillips, 2004.

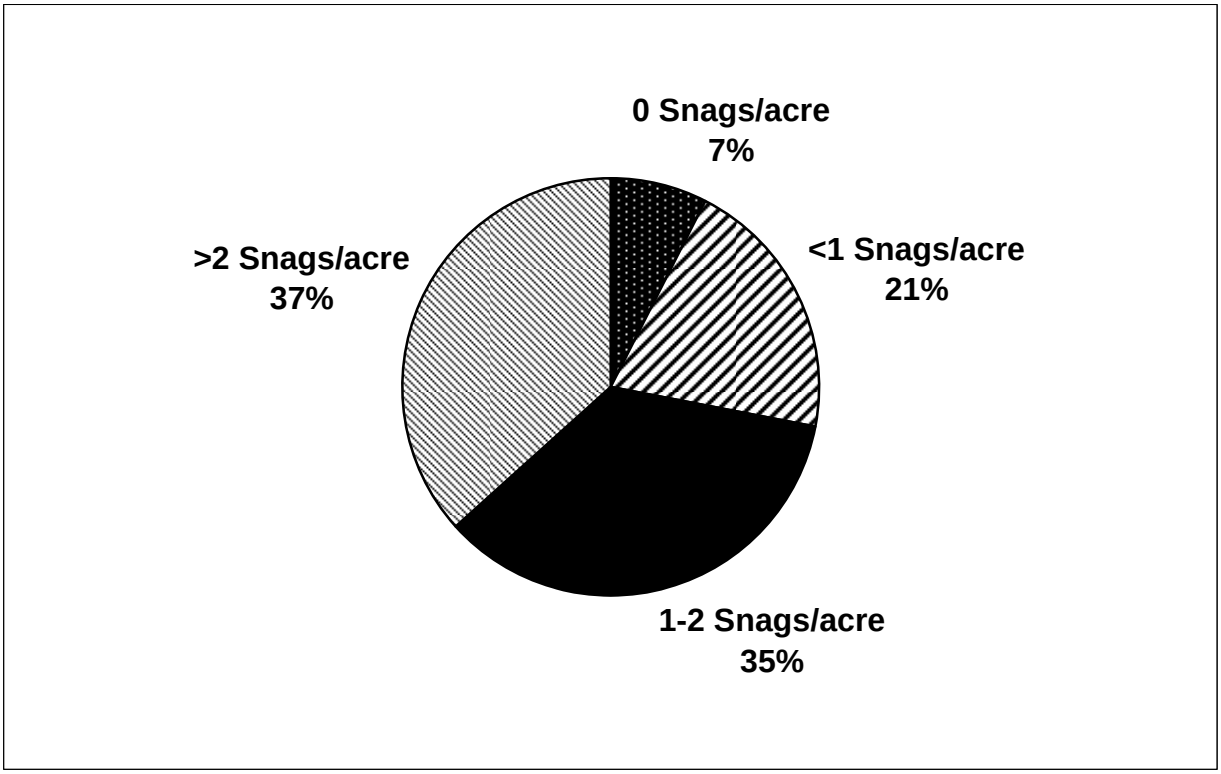

Figure 10. Number of snags per acre left after harvest (2001, 2002).
Source: Dahlman and Phillips, 2004.

C. DNR Logged Area Residue Analysis

In response to the growing interest in forest biomass harvests, the MN DNR Division of Forestry conducted a timber harvest residue study that was completed in August 2006 (Minnesota Department of Natural Resources, 2006). This study summarized the results of data collected on harvested sites randomly selected throughout Minnesota. Measurements were made on the sites after the merchantable timber was removed. The

purpose was to estimate how much wood material remained after the merchantable timber had been harvested from a site (Minnesota Department of Natural Resources, 2006). The residue measurements include dead wood that was on the site preharvest and residue that was left as a direct result from the timber harvest.[16]

Estimations for dead wood material were made for different logging methods. Tree length and shortwood logging methods leave the largest amounts of dead wood residue, 5.71 cords/acre and 5.64 cords/acre, respectively. These methods leave nearly three times as much FWD and CWD as full tree harvesting (2.04 cords/acre) (Table 18).

Table 18. Timber harvest CWD and FWD residue amounts by logging method.*

	ft^3/acre	**Cords/acre**	**Green tons/acre**	**% Fine woody debris**
Shortwood	513.2	5.64	12.7	24.5
Tree length	519.5	5.71	12.8	26
Full tree	185.8	2.04	4.6	20
Unknown	437.5	4.81	10.8	36.6

Source: Minnesota Department of Natural Resources 2006
*Conversion factor: 91 cubic feet = 1 cord
Coarse Woody Debris: Down woody debris greater than 2 inches in diameter
Fine Woody Debris: Down woody debris from 1 to 2 inches in diameter

Table 19 describes the amount of CWD and FWD material per acre by harvest type. Pure clear-cut harvests leave slightly more woody debris than the other two harvest types, but the difference between the three types is minimal.

Table 19. Timber harvest CWD and FWD residue amounts by harvest type.

	ft^3/acre	Cords/acre	Green tons/acre	% Fine woody debris
Clear-cut	523	5.75	12.9	25
Clear-cut w/reserve	499	5.48	12.3	27
Partial cut	491	5.4	12.2	26
Unknown	397	4.36	9.8	36.7

Source: Minnesota Department of Natural Resources, 2006.

Residue amounts were also calculated for different cover types (Table 20). Total residues amounts were larger for Aspen and other hardwoods (5.71 and 7.54 cords/acre) than lowland and upland conifers (4.3 and 4.7 cords/acre) (Table 20). Conifers also leave a larger percentage of FWD, while hardwoods leave more CWD.

Table 20. Timber harvest CWD and FWD residue amounts by cover type.

	ft^3/acre	Cords/acre	Green tons/acre	Fine woody debris %
Aspen	519	5.71	12.7	28
Other hardwoods	686	7.54	19	20
Lowland conifers	391	4.30	9.9	35
Upland conifers	429	4.71	10.5	31
Unknown	557	6.12	13.6	20

Source: Minnesota Department of Natural Resources, 2006.

[16] The dead wood estimates discussed in this section do not include residue left in slash piles on harvest sites. The MN DNR report (2006) estimates, in most harvests, residue left in slash piles is one cord per acre, or less.

Tables 18-20 provide summary information on deadwood residue left after Minnesota timber harvests for different logging methods, harvest types, and cover types. To estimate residue volumes in an area of interest, depending on the harvest type, logging method, and cover type, Thomas Burk from the University of Minnesota has developed an ArcGIS based geographic system using the data from the MN DNR study and Forest Service FIA data to estimate potential residue volumes after harvests.[17] However, these residue estimates will be far more reliable for large forest areas (multiple counties) than for small (one county) areas.

D. UPM Kymmene Forest Management Practices in Minnesota

The UPM Kymmene Blandin Paper Company has conducted yearly monitoring on harvest sites since 2002 (112 sample sites over a five-year period). Part of this effort was to collect the total amount of CWD left on a site after harvest. The monitoring does not specify what constitutes CWD, but twigs are not included. Also, the monitoring divides the CWD on the ground into residue that was present before harvest (Harvest Residuals), and residue that was left as a result of the harvest. Adding these two amounts together gives the total CWD on the ground after harvest (Total Residuals) (similar to the MN DNR study discussed directly above).

Table 21 shows the average CWD left on harvest sites by harvest type. Across all sites, UPM leaves nearly four cords/acre of CWD on the ground as a result of harvest activities and approximately nine cords/acre of total residue. More CWD is left after clear-cut harvests (9.98 cords/acre) than thinnings (6.75 cords/acre).

Table 21. Post-harvest residue on harvest sites in Minnesota by harvest type (2002-2006).

Harvest type	**Harvest residuals (cords/acre)**	**Total residuals (cords/acre)**
Clear-cut (clear-cut, regen cut)	4.30	9.98
Thinning	3.23	6.75
All types	3.98	9.04

Source: UPM Kymmene Blandin Paper Company, 2007.

Table 22 shows the average post-harvest CWD left on the site, separated by different types of equipment used during the harvest. The data suggests that conventional harvest equipment leaves slightly more CWD (9.46 cords/acre) than cut-to-length (CTL) equipment (8.08 cords/acre).

Table 22. Post-harvest CWD on UPM harvest sites in Minnesota by harvest equipment (2002-2006).

Harvest equipment	Harvest residuals (cords/acre)	Total residuals (cords/acre)
Conventional	4.29	9.46
CTL	3.50	8.08
All methods	3.98	9.04

Source: UPM Kymmene Blandin Paper Company, 2007.

[17] Personal communication with Thomas E. Burk, January 2007.

E. Certification Audits

As part of the certification process, recently harvested forest lands are audited to determine if certification standards are being met. As of December 1, 2005, the MN DNR 4,839,735 acres of forest land are FSC and SFI certified. The MN DNR FSC Assessment Report for 2005 (NSF International Strategic Registrations, Ltd., 2005) and the SFI Assessment Report for 2005 (Scientific Certification Systems, 2005) describe the level of MN DNR compliance with certification standards. Since the MN DNR owns nearly one-third of the state's forest land (4.8 million acres), the certification assessments can explain how dead wood is managed on a large portion of Minnesota's forest land. Appendix B provides the nearly complete auditor notes on MN DNR compliance with certification requirements related to deadwood and BMPs.

The FSC assessment report indicates that the MN DNR is following most BMPs for dead wood. They are leaving proper amounts of coarse woody debris after harvests, but there is room for improvement on slash treatments. Certification auditors issued a corrective action for treatment of leave trees (live standing trees) on MN DNR lands, but there was no request for improvements on the treatment of snags.

Similar to the FSC report, the SFI audit states that the MN DNR follows BMPs for dead wood. The only major noncompliance issue is the retention live trees on harvested lands. All aspects of dead wood management are in conformance with Minnesota's TH/FM guidelines.

V. SUMMARY AND CONCLUSIONS FOR DEAD WOOD MANAGEMENT

A. Forest Ownership Structure

Minnesota's nearly 15 million acres of timberland has a diverse ownership structure. No single ownership group owns more than 41% of the timberland and all major groups own at least 5% of the timberland area. NIPF landowners own the largest amount of timberland (6.1 million acres) and, of the 5 major ownership categories; forest industry owns the smallest amount (700,000 acres). The USDA Forest Service only owns 12% of the state's timberland. Aspen is by far the largest cover type (4.8 million acres) and the area of stand diameter size classes are fairly even across Minnesota's timberland.

B. Importance of Dead Wood

The best available science used to create the Minnesota TH/FM guidelines also explains the importance of dead wood in Minnesota. Coarse woody debris, fine woody debris, and snags all play an important role in sustainable forest management. Three specific forest benefits that rely on minimum quantities of dead wood include: wildlife habitat, soil productivity, and water quality.

C. Minnesota Dead Wood Inventory

Minnesota timberland has more than 270 million standing dead trees, with USDA Forest Service owned lands having a slightly higher density (standing dead trees per acre) than state, county, or private owners. There are approximately 4 dry tons of FWD and 6 dry tons of CWD per acre of timberland. Timberlands have an average of 7.87 cords of CWD per acre. USDA Forest Service lands average nearly twice as much CWD as state, county, or private owners. The large majority of CWD on the ground is small (3-8" diameter), but there is an average of 4 logs per acre greater than 13 inches. The current quality of CWD in Minnesota is very diverse. Decay class 3, which includes logs that have some slight decay, is the most common type of down log on timberland.

D. Guidelines for Dead Wood Management in Minnesota

Minnesota's voluntary TH/FM guidelines are the standard for sustainable forest management in the state. Currently, there is no specific section of the guidelines that provides recommendations for dead wood, but CWD, snags, and slash are all addressed in different areas throughout the guidelines. The guidelines recommend leaving 2-5 bark on down logs greater than 12 inches in diameter per acre scattered across the site. Snags are supposed to be left alone whenever possible. During timber harvesting, the guidelines recommend spreading slash across the site, instead of piling it, but exceptions can be made for certain site and harvest characteristics. Biomass harvest guidelines, which are expected to be complete in the summer of 2007, will provide more specific recommendations for dead wood management.

SFI and FSC certification standards and UPM Blandin use the TH/FM guidelines as their standard for dead wood management.

E. Dead Wood Practices in Minnesota

The Minnesota TH/FM guidelines are voluntary, but most public and corporate private forest managers comply with the recommendations. Results from survey by Kilgore et al. (2005) suggest that almost all of Minnesota's public and corporate private forest land is being managed in a way that is at least consistent with the recommended guidelines for dead wood. Much of the forest land may be characterized by dead wood management practices that actually exceed the guideline recommendations. The TH/FM guideline monitoring efforts indicate that two-thirds to three-quarters of the forest managers surveyed use the guidelines to plan forest management activities and timber harvests. NIPF owners are the only ownership group that does not use the guidelines most of the time and they appear to have the lowest level of guideline compliance.

The recommendations for treatment of snags are difficult to monitor because there is not a specific number of snags that should be left behind. Almost all monitored sites are leaving some snags behind. Only 7% of the sites did not have any snags left behind.

Slash should be redistributed across the site whenever possible and appropriate. Approximately 75% of the sites are leaving slash across the site, and not in piles. The guidelines give some latitude for different treatments of slash, depending on the site. Therefore, it is difficult to give an estimate for the level of slash guideline compliance.

Recommendations for CWD were met 79% of the time on the general harvest sites and 69% in RMZs. This suggests most sites follow the CWD recommendations, but there is still a significant portion that do not.

F. Timber Harvesting

There are approximately five cords/acre of CWD on the ground after timber harvests in Minnesota. This includes the amount of wood that was present pre-harvest and the amount created as a result of the harvest. Full-tree logging methods only leave 2 cords/acre, much less than shortwood and tree length methods. Aspen and other hardwood harvests generally leave more residue than conifer harvests.

Monitoring efforts for the amount of dead wood left after UPM Blandin harvests were not conducted with the same procedures as the general MN DNR residue study, so a comparison of the two monitoring efforts may not be completely accurate. However, it can provide a general understanding of how UPM harvests differ from a common harvest in Minnesota. The total amount of CWD left after harvests on UPM Blandin sites is approximately nine cords/acre, compared to five cords/acre for all Minnesota harvests. These data suggest that UPM Blandin leaves at least as much dead wood as the average Minnesota timber harvest, and it is likely that they leave more.

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GLOSSARY

CWD–Coarse Woody Debris. Downed woody materials that are a minimum size. The MN DNR report (2006) defines CWD as down woody debris greater than 2 inches in diameter on transect line. Minnesota's site-level timber harvest guidelines define it as stumps and fallen trunks or limbs of more than 6-inch diameter at the large end. FIA defines CWD as downed pieces of wood with a minimum small-end diameter of at least 3 inches and a length of at least 3 feet (Woodall and Williams, 2005).

Dead wood–A dead branch or part of a tree that is on the forest floor. This definition includes standing dead trees, coarse woody debris, fine woody debris, and slash, but not foliage.

DBH–Diameter at Breast Height

MN DNR–Minnesota Department of Natural Resources

DWM–Down woody materials. Dead organic materials on the forest floor.

FIA–Forest Inventory and Analysis program, run by the USDA Forest Service

Full tree logging method–Trees are felled and transported to the landing with branches and top intact. Generally, the full trees are processed at the landing. With the full-tree method, the limbs, tops, and wood residue are left in piles at the landing and must be disposed of.

FWD–Fine Woody Debris. The MN DNR report (2006) defines FWD as down woody debris from 1 to 2 inches in diameter on transect line. The FIA program defines it as downed woody materials that have a diameter less than 3 inches.

GEIS–Generic Environmental Impact Statement

MFRC–Minnesota Forest Resources Council

NIPF–Nonindustrial private forest owners, mostly family forests.

Other Federal–In the context of the FIA data, "other federal" means lands managed by the National Park Service, Bureau of Land Management, Fish and Wildlife Service, Department of Defense, or any other federal agency.

RMZ– Riparian Management Zones

SFRA– Minnesota's Sustainable Forest Resources Act

Shortwood (cut to length) logging method–Trees are felled, delimbed, and bucked to length directly in the stump area. Slash at landings is minimal since processing is done in the cutover.

Slash–Residual woody material created by logging or timber stand improvement (MFRC, 2005), could be CWD or FWD.

Snag–Standing dead tree

TH/FM guidelines–Minnesota's Site-level Timber Harvest and Forest Management Guidelines

Tree length logging method–Trees are felled, delimbed, and topped in the cutover. The tree lengths are bucked to pulpwood and logs at the landing, or can be left as is for tree-length hauling to the mill. Landing requirements are usually greater that shortwood method.

Unit conversions– 1 hectare = 2.471 acres
1 metric ton = 1.102 US tons
1 metric ton per hectare = 2.242 US tons per acre

UPM Blandin–UPM Kymmene, Blandin Paper Company

USDA–United States Department of Agriculture

APPENDIX A: Area of Timberland by Ownership, Forest Type, and Stand Size

Table 1: Minnesota timberland area by forest type and stand size class (acres).

	Stand size class				
Forest type	**Total**	**Large diameter**	**Medium diameter**	**Small diameter**	**Nonstocked**
Jack pine	356,195	66,224	136,232	153,739	0
Red pine	562,339	104,194	189,345	268,800	0
White pine	151,017	16,974	28,720	105,322	0
Balsam fir	393,152	226,368	114,736	52,049	0
White spruce	111,011	51,424	34,483	25,104	0
Black spruce	1,334,188	901,971	408,923	23,294	0
Tamarack	867,743	443,497	338,667	85,579	0
Northern white-cedar	571,573	65,774	255,283	250,516	0
Eastern red cedar	25,576	4,292	8,915	12,368	0
Other softwoods	5,663	2,215	2,209	1,238	0
Oak	791,449	29,375	185,130	576,488	456
Northern hardwoods	2,057,907	218,822	802,260	1,036,825	0
Lowland hardwoods	1,103,893	302,273	576,240	225,380	0
Cottonwood/Willow	106,997	58,303	2,425	46,269	0
Aspen	4,848,652	2,180,835	1,806,307	861,070	439
Birch	998,512	194,969	588,144	215,399	0
Balsam poplar	463,749	189,744	210,334	63,671	0
Nonstocked	228,063	0	0	0	228,063
Total	14,977,678	5,057,254	5,688,354	4,003,110	228,959

Source: USDA Forest Service, 2006.

Table 2. USDA Forest Service timberland area by forest type and stand size class (acres).

	Stand size class				
Forest type	**Total**	**Large diameter**	**Medium diameter**	**Small diameter**	**Nonstocked**
Jack pine	71,028	11,583	22,683	36,762	0
Red pine	148,473	14,004	48,140	86,329	0
White pine	46,731	9,580	1,552	35,599	0
Balsam fir	79,685	62,105	14,562	3,018	0
White spruce	26,041	8,300	9,492	8,249	0
Black spruce	213,250	121,097	83,176	8,978	0
Tamarack	69,892	32,951	23,780	13,162	0
Northern white-cedar	83,566	.	31,212	52,354	0
Eastern red cedar	0	0	0	0	0
Other softwoods	0	0	0	0	0
Oak	2,299	1,552	747	0	0
Northern hardwoods	143,212	33,530	38,815	70,868	0
Lowland hardwoods	65,629	25,983	32,079	7,567	0
Cottonwood/Willow	3,773	3,773	0	0	0
Aspen	531,409	238,460	181,117	111,833	0
Birch	236,156	49,792	129,878	56,486	0
Balsam poplar	23,483	1,494	4,527	17,461	0
Nonstocked	15,933	0	0	0	15,933
Total	1,760,561	614,202	621,760	508,666	15,933

Source: USDA Forest Service, 2006.

Table 3. Other federal timberland area by forest type and stand size class (acres).

	Stand size class				
Forest type	**Total**	**Large diameter**	**Medium diameter**	**Small diameter**	**Nonstocked**
Jack pine	14,328	2,204	6,847	5,276	0
Red pine	15,028	0	3,007	12,021	0
White pine	1,390	0	1,390	0	0
Balsam fir	16,688	7,314	9,374	0	0
White spruce	1,094	0	918	175	0
Black spruce	19,027	9,159	8,412	1,455	0
Tamarack	11,495	2,219	5,537	3,739	0
Northern white-cedar	12,039	0	6,044	5,995	0
Eastern red cedar	0	0	0	0	0
Other softwoods	0	0	0	0	0
Oak	14,503	2,373	1,990	10,140	0
Northern hardwoods	29,839	0	13,006	16,832	0
Lowland hardwoods	18,230	4,475	10,663	3,093	0
Cottonwood/Willow	8,243	0	0	8,243	0
Aspen	72,371	19,721	43,578	9,072	0
Birch	18,620	4,548	9,932	4,139	0
Balsam poplar	6,686	3,522	3,164	0	0
Nonstocked	3,164	0	0	0	3,164
Total	262,745	55,537	123,863	80,182	3,164

Source: USDA Forest Service, 2006.

Table 4. State government timberland area by forest type and stand size class (acres).

	Stand size class				
Forest type	**Total**	**Large diameter**	**Medium diameter**	**Small diameter**	**Nonstocked**
Jack pine	72,680	9,939	30,337	32,404	0
Red pine	122,594	26,629	49,346	46,620	0
White pine	16,968	3,638	773	12,557	0
Balsam fir	94,233	58,804	18,276	17,154	0
White spruce	41,358	24,020	9,271	8,067	0
Black spruce	631,582	466,428	158,226	6,928	0
Tamarack	451,807	254,702	167,903	29,202	0
Northern white-cedar	266,854	41,269	129,484	96,101	0
Eastern red cedar	3,093	0	3,093	0	0
Other softwoods	0	0	0	0	0
Oak	91,912	4,505	19,467	67,940	0
Northern hardwoods	286,549	30,918	130,165	125,466	0
Lowland hardwoods	232,015	68,218	139,528	24,269	0
Cottonwood/Willow	24,693	18,425	0	6,268	0
Aspen	1,163,456	566,453	408,069	188,934	0
Birch	223,813	62,615	123,424	37,775	0
Balsam poplar	127,695	55,066	57,899	14,729	0
Nonstocked	95,482	0	0	0	95,482
Total	3,946,783	1,691,627	1,445,261	714,414	95,482

Source: USDA Forest Service, 2006.

Table 5. County/municipal government timberland area by forest type and stand size class (acres).

	Stand size class				
Forest type	**Total**	**Large diameter**	**Medium diameter**	**Small diameter**	**Nonstocked**
Jack pine	52,570	12,373	28,404	11,792	0
Red pine	50,333	11,513	5,958	32,862	0
White pine	14,300	3,005	6,101	5,195	0
Balsam fir	55,850	25,804	21,828	8,218	0
White spruce	6,803	3,980	1,972	851	0
Black spruce	220,910	155,903	64,260	747	0
Tamarack	139,036	75,808	50,369	12,858	0
Northern white-cedar	89,390	6,079	40,749	42,561	0
Eastern red cedar	0	0	0	0	0
Other softwoods	0	0	0	0	0
Oak	51,861	5,976	20,261	25,624	0
Northern hardwoods	244,362	25,649	111,454	107,259	0
Lowland hardwoods	113,362	29,191	61,501	22,670	0
Cottonwood/Willow	5,184	3,727	0	1,457	0
Aspen	857,773	395,076	299,526	163,171	0
Birch	163,808	20,655	100,597	42,555	0
Balsam poplar	55,338	16,191	37,653	1,494	0
Nonstocked	23,442	0	0	0	23,442
Total	2,144,321	790,927	850,635	479,317	23,442

Source: USDA Forest Service, 2006.

Table 6. Forest industry timberland area by forest type and stand size class (acres).

	Stand size class				
Forest type	**Total**	**Large diameter**	**Medium diameter**	**Small diameter**	**Nonstocked**
Jack pine	42,173	15,869	17,087	9,217	0
Red pine	48,449	27,011	18,432	3,007	0
White pine	6,087	0	2,923	3,164	0
Balsam fir	27,167	15,537	11,630	0	0
White spruce	14,070	12,525	0	1,545	0
Black spruce	34,329	23,425	10,904	0	0
Tamarack	7,698	4,534	3,164	0	0
Northern white-cedar	23,552	3,007	13,094	7,451	0
Eastern red cedar	0	0	0	0	0
Other softwoods	0	0	0	0	0
Oak	7,163	1,582	1,374	4,207	0
Northern hardwoods	33,627	3,916	10,211	19,500	0
Lowland hardwoods	39,246	14,707	21,375	3,164	0
Cottonwood/Willow	9,108	9,108	0	0	0
Aspen	342,362	240,886	73,497	27,539	439
Birch	30,111	6,113	14,652	9,346	0
Balsam poplar	33,995	15,540	11,512	6,943	0
Nonstocked	6,139	0	0	0	6,139
Total	705,276	393,760	209,854	95,085	6,578

Source: USDA Forest Service, 2006.

Table 7. NIPF timberland area by forest type and stand size class (acres).

	Stand size class				
Forest type	**Total**	**Large diameter**	**Medium diameter**	**Small diameter**	**Nonstocked**
Jack pine	103,415	14,255	30,874	58,286	0
Red pine	177,462	25,039	64,463	87,961	0
White pine	65,540	752	15,982	48,807	0
Balsam fir	119,529	56,804	39,067	23,658	0
White spruce	21,644	2,599	12,829	6,216	0
Black spruce	215,090	125,959	83,946	5,186	0
Tamarack	187,816	73,283	87,914	26,619	0
Northern white-cedar	96,172	15,419	34,700	46,052	0
Eastern red cedar	22,483	4,292	5,823	12,368	0
Other softwoods	5,663	2,215	2,209	1,238	0
Oak	623,711	13,387	141,291	468,577	456
Northern hardwoods	1,320,318	124,810	498,609	696,899	0
Lowland hardwoods	635,412	159,699	311,095	164,617	0
Cottonwood/Willow	55,995	23,270	2,425	30,300	0
Aspen	1,881,281	720,239	800,520	360,522	0
Birch	326,004	51,247	209,660	65,097	0
Balsam poplar	216,551	97,931	95,577	23,043	0
Nonstocked	83,905	0	0	0	83,905
Total	6,157,990	1,511,201	2,436,982	2,125,447	84,361

Source: USDA Forest Service, 2006.

APPENDIX B: FSC and SFI Certification Audit Notes for Minnesota DNR Lands

Table 1. Audit notes for Minnesota DNR lands' compliance with FSC Lake States Region Standards for Guideline Compliance and Deadwood Management.

5.3. Forest management should minimize waste associated with harvesting and on-site processing operations and avoid damage to other forest resources.	**90- The audit team has determined that there is outstanding overall conformance with this Criterion.**
5.3.a. Adequate quantities and a diversity of size classes of woody debris (considered a reinvestment of biological capital under this criterion—not an economic waste) are left on the forest floor to maintain ecosystem functions, wildlife habitats, and future forest productivity.	DNR management of woody debris is directed by the Site-level Guidelines, which provide clear and detailed guidance on this topic. Most sites inspected contained adequate CWD. In some cases large CWD was minimal. On a somewhat related issue, DNR sales have a wide variability in treatment of slash. Some slash treatments appear to be less successful than others. For example, returning slash to the site on one sale caused significant compaction and hindered natural regeneration. On another site, heavy site slash was spread for almost an acre near the landing and caused lack of vegetative reproduction. There is room for improvement in slash treatments.
5.3.b. The loss and/or waste of merchantable forest products is minimized.	The audit team noted DNR's strong conformance with this indicator because: • we observed excellent utilization across nearly all sites; • DNR forester/appraiser sets utilization standards for each species and product on each timber sale. These specifications are based on statewide criteria, adjusted for local conditions. Appraiser has the ability to charge logger for un-utilized material left on site; • Prices for all species, products, and grades are at or near all-time high levels, with most mills seeking more fiber than they can obtain; • Mechanized (cut-to-length) logging equipment, designed to ensure excellent utilization, is increasingly employed.
C6.3.c. Natural cycles that affect the productivity of the forest ecosystem	**75**
6.3.c.1. Biological legacies of the forest community are retained at the forest and stand levels, consistent with the objectives of the management plan, including but not limited to: large live and declining trees, coarse dead wood, logs, snags, den trees, and soil organic matter.	The audit team observed substantial variation across units and among individual foresters—in the extent and manner of retaining legacy trees and large live declining trees. The audit team felt more work is needed and CAR 2005.4 was issued in response. See 6.3.a.5.
6.3.c.2. Forest management practices maintain soil fertility and organic matter, especially in the A horizon, while minimizing soil erosion and compaction. If degradation of soil quality occurs, as indicated by declining fertility or forest health, forest owners or managers modify soil management techniques.	The team observed forest management practices conducted with sensitivity to erosion, compaction, and other soil fertility issues. These issues are very well covered in the site-level guidelines. The team that developed the FRC's soil productivity guidelines considered calcium depletion in its guidelines for aspen management on well-drained soils.

C6.5. Written guidelines shall be prepared and implemented to control erosion; minimize forest damage during harvesting, road construction, and all other mechanical disturbances; and to protect water resources.	**85-The audit team concludes that there is clear overall conformance with this Criterion. While unauthorized motorized access is a concern, the audit team felt this issue was best addressed under Criterion 1.5.**
6.5.a. A set of forestry best management practices (BMPs), approved by the state forestry agency or otherwise appropriate jurisdiction (e.g., BIA), that address water quality and soil erosion is adhered to (see also 1.1.b). These guidelines may include provisions on riparian management zones (RMZs), skidding, access roads, site preparation, log landings, stream crossings, disturbance of sensitive sites, and wetlands.	• Site-level Guidelines are comprehensive in their coverage of water quality, soil erosion, riparian management zones, and other BMP issues. • DNR staff demonstrated a solid understanding of Site-level Guidelines covering water quality and soil erosion, and implementation was overall strong, with a few isolated exceptions. • The ECS includes a soils guide titled "Acceptable Operating Season to Minimize Compaction and Rutting by Native Plant Community (NPC)". However, because ECS/NPC is not yet implemented this was of little use.
6.5.b. At a minimum, implementation of BMPs and other resource protection measures will result in the following:	The Minnesota DNR uses the Site-level Guidelines as the basis for BMPs. The DNR implements an extensive program to ensure that these BMPs are utilized to minimize logging damage protect streams, lakes, and other water bodies. The program includes the use of trained professional foresters or forest technicians to design and supervise all treatments, interdisciplinary review, a multi-level management approval process, site inspections during and following treatments, internal monitoring of a sample of timber harvests, and external monitoring by the Minnesota Forest Resources Council.
Plans for site preparation specify the following mitigations to minimize impacts to the forest resources: 1) Slash is concentrated only as much as necessary to achieve the goals of site preparation and the reduction of fuels to moderate or low levels of fire hazard.	Site-level Guidelines adequately address site preparation. The audit team observed strong implementation of guidelines for site-preparation. Of particular note: • rock raking has been reduced as a site prep technique, which has mitigated soil degradation concerns; • 80-90% of all sites regenerate naturally; • Scarified sites for planting generally followed natural contours of topography.

Source: Scientific Certification Systems, 2005.

Table 2. Audit notes for Minnesota DNR lands' compliance with SFI Standards for Local Guideline Compliance.

3.1.1 Program to implement state or provincial equivalent BMPs are utilized during all phases of management activities.	FC	The Minnesota DNR has an impressive program to ensure that BMPs are utilized during all phases of management, including the use of trained professional foresters or forest technicians to design and supervise all treatments, interdisciplinary review including fisheries biologists where warranted, multi-level management approval process, site inspections during and following treatments, internal monitoring of a sample of timber harvests, and external monitoring by the Minnesota Forest Resources Council.
3.1.2 Contract provisions that specify BMP compliance.	FC	Reviewed many timber permits for the Logging Contract and confirmed provisions that specify BMP compliance. Reviewed Permit Condition #18 on each permit document, which reads as follows: "18. Water Quality, Wetlands, Riparian Management Zones–The persons affected by this permit shall comply with specific best management practices, timber harvesting and forest management guidelines as indicated on the permit form under special conditions and as indicated on the attached Timber Appraisal Report (NA-2136) [M.S. 89A.05, 103G.2212 103G.2241(7)]."
3.1.4 Monitoring of overall BMP implementation	FC	Confirmed that monitoring includes site inspections during and following treatments, internal monitoring of a sample of timber harvests, and external monitoring by the Minnesota Forest Resources Council. Confirmed Pre-guideline monitoring, which showed that not all of the BMPs were being consistently followed on Minnesota DNR lands prior to 2002. Post guideline monitoring began in 2004 and will continue in future years.
4.1.4 Development and implementation of criteria, as guided by regionally appropriate science, for retention of stand-level wildlife habitat elements (e.g., snags, mast trees, down woody debris, den trees, nest trees)	Min	Criteria for stand-level wildlife habitat elements are included in the FRC's site-level guidelines, which the DNR treats as minimum standards. Inconsistent application of the retention (green tree) guidelines is apparent, with some projects meeting the guidelines well. In many cases the individually retained trees did not meet the guidelines for the size of the retained trees, the type of retained trees (selection for wind firmness).

Source: NSF International Strategic Registrations, Ltd., 2005.